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IMPLEMENTATION OF THE DECLARATION ON THE DENUCLEARIZATION OF AFRICA

South Africa's nuclear-tipped ballistic missile capability**

Report of the Secretary-General

1. In its resolution 44/113 B of 15 December 1989, the General Assembly called upon the Secretary-General, with the assistance of a group of qualified experts, to investigate recent reports that collaboration between Israel and South Africa had resulted in the development by South Africa of a nuclear-tipped missile, bearing in mind their implications for the implementation of the policy of denuclearization of Africa and for the security of African States and, in particular, the front-line and other neighbouring States; requested the Secretary-General to submit a report on his investigation to the Assembly at its forty-fifth session; and also requested him to report to it at its forty-fifth session on the military assistance that South Africa was receiving from Israel and any other sources in advanced missile technology as well as the supporting technical facilities.

2. Pursuant to that resolution, the Secretary-General has the honour to transmit herewith to the General Assembly the report on South Africa's nuclear-tipped ballistic missile capability.

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* Reissued for technical reasons.

** In addition, two annexes prepared in connection with the report, addressing technical aspects of nuclear weapons, fissile materials, missiles and space-launch vehicles, are available in the Reference Library of the Department for Disarmament Affairs.

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ANNEX

South Africa's nuclear-tipped ballistic missile capability

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FOREWORD BY THE SECRETARY-GENERAL

It has long been held that South Africa's military posture, including its plans to develop a nuclear-weapon capability, has been most directly related to the preservation of the system of apartheid and a policy of intimidation of States within the region. In addressing the question of South African nuclear capability, the General Assembly has vigorously condemned any overt or covert attempt by South Africa to introduce nuclear weapons into the African continent and has called upon all States, corporations, institutions and individuals to terminate all forms of military and nuclear collaboration with it.

At its forty-fourth session, the Assembly expressed concern about reports that collaboration between Israel and South Africa had resulted in the development by South Africa of a nuclear-tipped missile and called upon me to investigate those reports with the assistance of a group of qualified experts. The present document is submitted in pursuance of that request.

The preparation of the present report has coincided with critical and potentially far-reaching developments within South Africa. For the first time, the Government of South Africa has provided hope for real change in the unacceptable social and political structures created in South African society. Indeed, it is the considered view of the experts who have prepared the report that "the dramatic changes in South Africa and its immediate subregion may have substantially modified, if not altered, the context within which this and other earlier studies were made". This new development, in which the sustained struggle of the oppressed majority together with effective military and trade embargoes have played an essential role, has significantly affected previous motivations of South Africa's reliance on force and military might to preserve the status quo. The Government of South Africa has publicly declared its resolve to dismantle the apartheid system with the final aim of achieving a totally new and just constitutional dispensation that would assure equal rights and opportunities for all. For these reasons, South Africa may no longer wish to pursue vigorously its programmes of nuclear-weapon capability or ballistic missiles. Instead, South Africa may wish to gear its efforts towards the peaceful application of nuclear energy. In this context, its long-standing co-operation with Israel, particularly in the military field, may no longer have the same significance and relevance as it had in the past.

Nevertheless, the fact remains that South Africa, with or without nuclear-weapon and ballistic missile capability, remains a formidable military Power in the continent of Africa. The threat it still represents for the security of African States and, in particular, the front-line and other neighbouring States can only be reassessed in the light of the ongoing internal changes in South Africa and, particularly, of how soon these changes become politically irreversible.

A tangible proof of South Africa's determination to abandon the policy of military intimidation would be its expeditious accession to the Treaty on the Non-Proliferation of Nuclear Weapons and the opening of all its nuclear facilities to international inspection. Recent statements concerning its intention to this effect are most encouraging, but until they are implemented fully the concerns will

not be completely put at rest. South Africa's accession to the Non-Proliferation Treaty will not only strengthen confidence in the region, but would also remove one of the main obstacles for transforming the continent into a nuclear-weapon-free zone.

I wish to express my sincere appreciation to the panel of experts who assisted me in the preparation of the present report and whose recommendations were unanimous. I submit their report to the General Assembly for its consideration.

LETTER OF TRANSMITTAL

10 September 1990

Sir,

The undersigned consultant experts, appointed by you to assist you in investigating "recent reports that collaboration between Israel and South Africa has resulted in the development by South Africa of a nuclear-tipped missile", as requested in paragraph 5 of resolution 44/113 B of 15 December 1989, have the honour to submit herewith a unanimously approved report.

In preparing this report, the consultants, pursuant to paragraph 17 of the same resolution, have also addressed the question of "the military assistance that apartheid South Africa is receiving from Israel and any other sources in advanced missile technology as well as the supporting technical facilities".

The work was carried out from April to September 1990. During that time, various contacts and consultations were carried out with the Chairman of the Group of African States and representatives of the Organization of African Unity (OAU) and interested African delegations, both at Geneva and Vienna; officials of the International Atomic Energy Agency (IAEA) and relevant member delegations of IAEA, including the representatives of the three Depositary Governments of the Treaty on the Non-Proliferation of Nuclear Weapons; the Chairman of the Board of Governors of IAEA; and representatives of interested member delegations of the Conference on Disarmament. In addition, a visit was carried out to the African region, during which consultations were held with OAU officials at that Organization's headquarters and with government representatives of the front-line and other interested States.

We wish to express our gratitude for the invaluable assistance that was provided by the staff of the Department for Disarmament Affairs throughout the preparation of the report. We wish, in particular, to convey our appreciation to Mr. Yasushi Akashi, Under-Secretary-General for Disarmament Affairs, Mr. Prvoslav Davinic, Chief of the Monitoring, Analysis and Studies Branch, and to Mr. Ogunsola Ogunbanwo, Senior Political Affairs Officer, who served as Secretary of the Group.

Accept, Sir, the assurances of our highest consideration.

(Signed) Shahram CHUBIN

(Signed) Bhupendra JASANI

(Signed) Aaron KARP

His Excellency
Mr. Javier Pérez de Cuéllar
Secretary-General of the United Nations
New York

I. INTRODUCTION

A. Mandate

1. On 15 December 1989, the General Assembly adopted resolution 44/113 B in which it, inter alia, took note "with great concern of recent reports that collaboration between Israel and South Africa has resulted in the development by South Africa of a nuclear-tipped missile". In this connection, the General Assembly requested the Secretary-General to investigate those reports and report to it at its forty-fifth session. The relevant paragraphs of the resolution read as follows:

> "The General Assembly,
>
> "...
>
> "5. Calls upon the Secretary-General, with the assistance of a group of qualified experts, to investigate those reports, bearing in mind their implications for the implementation of the policy of denuclearization of Africa and for the security of African States and, in particular, the front-line and other neighbouring States;"
>
> "...
>
> "17. Also requests the Secretary-General to report to the General Assembly at its forty-fifth session on the military assistance that apartheid South Africa is receiving from Israel and any other sources in advanced missile technology as well as the supporting technical facilities."

2. In preparing the report, the experts have interpreted the mandate as calling for a study both of South Africa's nuclear programme and of its ballistic missile capabilities, and drawing appropriate conclusions on that basis. Since the first aspect of this issue has been the subject of several reports of the Secretary-General to the General Assembly, 1/ the current investigation focuses largely on the relevant new developments in this regard in the period October 1989-August 1990.

3. As regards the second aspect, which represents a completely new development, the report deals with a number of questions related to the South African missile programme, particularly those pertaining to its long-range ballistic missile capability. Among the questions discussed are the following: Does South Africa currently possess an operational ballistic missile or an active research and development programme? To what extent do South Africa's missile activities rely upon Israeli technology or assistance? Is South Africa capable of arming ballistic missiles with nuclear weapons and other means of mass destruction?

B. Sources of information

4. In view of the secrecy surrounding the activities that are the subject of this investigation, the information on such matters is neither easy to obtain nor to interpret unequivocally. For example, the relevant technologies tend to be of a dual nature, as in the case with missiles that could be easily adapted to launch satellites. In addition, it is difficult to obtain reliable information from public or open sources. The information that is available falls into four categories.

5. First are official South African disclosures, public reports and displays. Officially released information tends to be thorough and, on balance, reliable. 2/ Usually, however, details about specific projects are made available only after development is complete. The most important source of official data about South African weapons are specifications for conventional weapons offered for sale on the international arms market.

6. Second are foreign intelligence reports from satellite, electronic or clandestine sources. These are made available occasionally, as in the case of the 1977 Kalahari nuclear test site, which was revealed by the Union of Soviet Socialist Republics, or the 1979 South Atlantic flash event detected by the United States of America. Such information can be valuable but tends to be rare, incomplete and sometimes ambiguous.

7. Third, foreign criminal investigations or prosecutions tend to be the most thorough source on some specific projects. These are available only when an individual or company has been investigated for illegally assisting a South African military project. This was the case of a Canadian citizen convicted in the United States in 1979 for his work on the G-5 howitzer. More recently there has been a comparable case involving the attempts of South African agents to buy surface-to-air missile plans stolen from the United Kingdom of Great Britain and Northern Ireland.

8. Finally, press reports are by far the most numerous sources. Investigative journalism has repeatedly furnished the first evidence of South African military projects, but press reports also need to be carefully scrutinized and confirmed from other sources. In the absence of access to government intelligence information, the present report necessarily had to rely on press coverage. For example, press reports have been used as the leading source of information on South Africa's activities in long-range rockets. Nevertheless, limited confirmation of reported data has been obtained from official South African announcements and foreign intelligence disclosures.

C. Scope of the report

9. In examining South Africa's nuclear and missile programmes, the report attempts to establish the facts about South Africa's capabilities and, to the extent possible, to determine its intentions. This necessarily requires a focus on the technical aspects of those programmes and on the ongoing investment in various industries that might service them. However, an analysis of the technical

feasibility or capability cannot be divorced from, or seen in isolation from the political context. Lately, this political context has become particularly relevant in view of the dynamic changes now taking place at the international level, as well as domestically within South Africa and regionally in southern Africa.

10. The improvement in East/West relations has reduced some of the tensions in several regional conflicts, including some in southern Africa. The prospect of continued and greater co-operation between East and West in resolving regional conflicts is promising. This and the possibility of co-ordinating approaches in preventing future conflicts will most certainly affect the international climate of the 1990s. The calculations of those States likely to find themselves the object of international condemnation will be especially affected. Such States, including South Africa, may face increasingly severe and effective international measures and sanctions undertaken to foster desired changes. Given the international community's new resolve and increasingly effective means through which to implement its policies, the offending States may find it in their interests to conform to international opinion.

11. The political changes within South Africa itself, should they continue in this present direction, might have far-reaching implications for peace and security in the region and beyond. The shifting political environment of South Africa is thus the distinguishing feature of the era and of necessity the present report has had to consider its implications for traditional security assessments and priorities of States of the region. It is therefore very important to assess whether or not, and if so, to what extent the dominant security rationales of the past several decades have been transformed and overtaken.

12. To some extent the pace of military research and development and the political and security considerations supposedly driving them forward may well find themselves already out of step. The gap between these two may be narrowed as other demands make themselves felt and other priorities assert themselves. This disjunction between the changed political context, which alters the traditional security rationale and makes desirable and feasible region-wide co-operation on a range of issues, and the momentum of research and development are issues to which the report returns both implicitly and explicitly.

Notes

1/ See, for instance, A/35/402 and Corr.1 and A/39/470.

2/ The only major South African claim about its military-industrial programmes subsequently shown to be false was a statement in the 1973 Defence White Paper that the French Dassault Mirage F-1 fighter plane was already in production in South Africa. In fact, only local assembly from knock-down kits was undertaken, starting a year later. Plans for co-production were dropped in 1977. See Signe Landgren, Embargo Disimplemented: South Africa's Military Industries, New York, Oxford University Press for SIPRI, 1989.

II. SOUTH AFRICA'S POLICIES AND REGIONAL SECURITY

A. Past assessments

13. South Africa's persistent policies of apartheid, on the one hand, and continuous threats to the security of neighbouring countries, on the other, have been a source of serious concern of the United Nations over the years. In the past, this concern also set the tone for the consideration of issues relating to the political and strategic landscape of South Africa, in particular, and the African continent, in general. The internal changes that have occurred in South Africa since the beginning of 1990 and the extent to which they will continue are bound to affect both the political atmosphere in the region and the security perceptions of South Africa.

14. To appreciate the depth and significance of changes in southern and South Africa in recent months as they affect the security environment, it is necessary to compare them with the recent past. A study on South Africa's plan and capability in the nuclear field, 1/ which the Secretary-General submitted to the General Assembly in 1980, provides the most eloquent analysis of the situation based on assumptions and a context that existed at the time.

15. The study observed: 2/

> ... Any discussion of South Africa's military and political posture ... must start from the special situation created by apartheid, not only in South Africa itself but in the region as a whole. Traditional concepts of national security interests, threat perceptions, and defence may apply only to a limited extent in a situation where the military and defence policy of that country is aimed chiefly at maintaining by any necessary means the domination of the white minority. In fact, the greatest threat to peace in the region stems from a racist régime's denial of basic rights to the overwhelming majority of the population and its willingness to use strong repressive means, both internally and externally, to preserve its interests and privileges. (emphasis added)

16. The study went on to note that South Africa's policy of seeking to gain the co-operation of the more conservative black African States had given way to a strategy of "Fortress South Africa". 3/ It recorded an increase in defence spending, a build-up of conventional forces and noted that the objective of training and acquisitions was to "carry out extensive military operations on or across its borders with conventional forces while at the same time suppressing internal uprising". 4/

17. The study also noted that the military had become more influential in decision-making and that there was an "increasingly explicit and less ad hoc outward extension of the South African strategic zone to embrace events not simply on that country's own immediate borders but also in neighbouring countries". 5/

18. The study found that such a unilateral definition of security interests and attacks against neighbouring States had been matched by the complete absence of movement towards reform or power-sharing politically on the domestic front. In addition, South Africa's readiness to accept its international isolation coupled with its tendency to look toward other "'garrison States' similarly suffering from varying degrees of international isolation", further confirmed its strategy of "Fortress South Africa". 6/

19. Against this background, the study assessed the military and political dimensions of South Africa's nuclear weapons posture, taking as the fundamental premise for that analysis the fact that apartheid was the main determinant of South Africa's security stand.

20. Among the possible incentives and elements of a rationale for South Africa to embrace the nuclear-weapon option, the study cited: as a deterrent or intimidatory instrument against neighbours; as an assertion of defiance and desperation (presumably a last-resort device); and as a means of intimidating black South Africans and lessening the risk of internal unrest while boosting the morale of the beleaguered whites. The study also suggested that rather than deploy or openly test nuclear weapons, South Africa might seek to follow and exploit a policy of ambiguity of latent proliferation. 7/

B. Recent developments

21. The dramatic changes within South Africa and its immediate subregion may have substantially modified if not altered the context within which this and other earlier studies were made. Put differently: the incentives or rationales for South Africa's development of a nuclear weapon and the development of a ballistic missile capability for military purposes may have been dramatically reduced.

22. In 1985 one expert referred to nuclear weapons as South Africa's "ace in the hole". 8/ Yet that same instrument, from the vantage-point of a new decade, appears much less relevant. The same expert writing in 1988 considered the possible military utility of nuclear weapons for South Africa. After noting various possible uses of nuclear weapons by South Africa in general - (a) to deter and punish regional adversaries; (b) to deal with internal revolt; and (c) to deal with a combination of internal revolt and external invasion (possibly by a Power foreign to the continent) - he considered as unlikely the use of tactical nuclear weapons to break up demonstrations and/or as shots fired "across the bow" to warn off external Powers. He concluded, however, that the retention of nuclear weapons as a "last resort" device "is the only remotely feasible use of nuclear weapons", which he otherwise saw as "largely irrelevant" in the near and medium term. 9/

23. This is not to say that the apartheid régime of South Africa may not still wish to take advantage of the potential (or continuing) political value of possessing a strong nuclear-weapons option. The possible considerations include: (a) as a bargaining chip to be used vis-à-vis Western States for diplomatic leverage, for example, as a quid pro quo for access to technology in exchange for renunciation of the option; (b) as an insurance policy against the possibility of a

reversal in the process toward liberalization and power-sharing; (c) as a bargaining card in domestic negotiations within the new South Africa; and (d) as an option against an uncertain future. Whether there would be any particular incentive or motive for developing a long-range means of delivery in South Africa's strategic situation is also a matter for debate. The question, however, is whether the maintenance of this option is of high priority in the light of the political price attached to it - regionally and internationally.

24. The pertinent question for the present report is the degree to which South Africa remains the same régime and the extent to which it continues to define security primarily by reference to military power and to see its regional environment as hostile and itself as embattled and alone.

25. While apartheid has not yet been totally dismantled, initial steps toward meaningful reform and power-sharing have been taken. There are reasonable signs that this process may continue, however, unevenly. In parallel with this, the seeds of regional reconciliation are being sown. On the reasoning of the 1980 study quoted above, these domestic transformations must at some point affect the security policy of South Africa, making it a more conventional State with a more "rational" cost-calculus and demeanor, and with a different assessment of its priorities.

26. As two experts on military policy have observed: "judgements of interest and value (are) essentially political rather than strategic ... (and) are affected and shaped by political processes both operating within the governmental structure and impacting on it from the outside". 10/

27. South Africa's domestic changes will alter its regional policies and perspectives with a consequent re-definition of its strategic priorities. It is this changed regional context, in conjunction with a major transformation in South Africa's domestic politics and society, that significantly transforms the assessment of that State's incentives for acquiring nuclear-capable missiles.

Notes

1/ Study on South Africa's plan and capability in the nuclear field (United Nations publication, Sales No. E.81.I.10).

2/ Ibid., para. 54.

3/ Ibid., para. 56.

4/ Ibid., para. 57

5/ Ibid., paras. 58 and 59.

6/ Ibid., paras. 59-61.

Notes (continued)

7/ Ibid., paras. 64-67.

8/ Robert Jaster, in Henry Bienen and William Flotz (eds.), Arms and the African: Military Influences on Africa's International Relations, New Haven, Yale, 1985, p. 152.

9/ Robert Jaster, The Defence of White Power: South African Foreign Policy under Pressure, London: MacMillan, for the International Institute for Strategic Studies, 1988, pp. 170 and 171.

10/ Alexander L. George and Richard Smoke, Deterrence in American Foreign Policy: Theory and Practice, New York, Columbia University Press, 1974, p. 557.

III. SOUTH AFRICA'S NUCLEAR CAPABILITY

A. Background

28. With its long experience and technical sophistication, South Africa's nuclear programme places the country among those on the top of the list of nuclear threshold States. South Africa is also one of a small number of threshold countries who are not party to the Treaty on the Non-Proliferation of Nuclear Weapons (resolution 2737 (XXII), annex). Consequently, much of its nuclear research is not covered by the safeguards and inspections of the International Atomic Energy Agency (IAEA). Owing in large part to the apartheid policies of the white minority Government and repeated military interventions into neighbouring States, South Africa's nuclear programme has been the cause of special international attention and condemnation.

29. International concern regarding South African nuclear intentions turned into outright alarm following two incidents in the late 1970s. In August 1977, Soviet intelligence satellites revealed the existence of what appeared to be an underground nuclear-weapons-test site in the Kalahari Desert. Then on 22 September 1979 a United States reconnaissance satellite recorded flashes indicative of a nuclear explosion in the South Atlantic, in the area of South Africa and Antarctica. The event has been described variously as a possible nuclear test by South Africa, by another country or as an unexplained "zoo event" such as a small meteor collision with a satellite. 1/

30. Despite uncertainty, the two events helped galvanize the determination of the United Nations to take forthright action. The study prepared by the Secretary-General of the United Nations in 1980 concluded that: 2/

> "it cannot be doubted that, had it decided to do so, South Africa by mid-1979 could have produced sufficient weapon-grade uranium for at least a few nuclear weapons .... There is no reason to doubt the broadly accepted conclusion that South Africa is capable of constructing a first generation fission weapon of moderately sophisticated design."

Two subsequent United Nations reports supported the conclusions that South Africa continued to receive foreign nuclear technology and to expand its supplies of fissile materials, increasing its nuclear-weapons potential. 3/

31. Rising international concern with South Africa's apartheid policies in general, and its nuclear programme in particular, led to continuously stronger pressure. In 1977 South Africa lost its seat on the IAEA Board of Governors. In 1979 its credentials were rejected by the IAEA General Conference and, since then, South Africa has not participated in IAEA deliberations. Also since 1979 the United Nations Disarmament Commission has kept the question of South Africa's nuclear capability on its agenda, assuring that the issue receives prominent attention. 4/

32. The African Group of States and the Western States have held somewhat different views concerning mainly the question of absolute certainty of South Africa's nuclear-weapon capability and the degree to which it should be singled out for greater condemnation than other NPT hold-outs. Nevertheless, Western Governments, too, have responded unilaterally to growing concern, by severing their relationships with South Africa in the nuclear field. The United States, after having halted sales of nuclear fuel in 1975, terminated all nuclear commerce with South Africa in 1980. After internal controversies over implementation of this policy, the United States Congress passed a stronger nuclear embargo in 1986. In the mid-1980s nuclear embargoes were also agreed by the Commonwealth nations (with the exception of the United Kingdom) and the European Community. In July 1985 France, previously South Africa's leading nuclear supplier, announced that it would not approve new nuclear agreements. This left Israel as South Africa's most important remaining source of nuclear technology and assistance. 5/

33. Furthermore, since 1987 the IAEA General Conference has considered a resolution to suspend South Africa's membership in the organization. Although largely a symbolic step, suspension would be significant since this is the last major international organization to which South Africa belongs. 6/

34. In view of the statement of 21 September 1987 by the South African Prime Minister announcing that his Government "hopes that it will soon be able to sign the NPT and has decided to open discussions with others to this end", 7/ the IAEA General Conference agreed to defer consideration of suspension in order to give the South African initiative a chance. Some observers interpreted the statement as a possibly insincere manoeuvre to preserve South Africa's IAEA membership, but the announcement also aroused hope that South Africa would soon abandon the secrecy and ambiguity that have surrounded its nuclear programme for some 20 years, ending the doubts that fuelled suspicion of military intentions.

B. South Africa's nuclear infrastructure

35. At the core of South African nuclear capabilities is a diversified and technologically sophisticated nuclear establishment operated by the South African Atomic Energy Corporation (AEC). AEC was established in 1949 to capitalize on expertise acquired through nuclear co-operation with the United Kingdom and the United States in exchange for sales of natural uranium. 8/ The nuclear programme accelerated in the mid-1960s as AEC began to plan for a complete nuclear fuel cycle, fully under national control and mostly free of international safeguards and inspections. This goal was largely accomplished by the late 1980s.

36. South Africa's first research reactor, the 20 megawatt SAFARI-I, was purchased from the United States and went into operation in 1965. This safeguarded reactor is fuelled with roughly 14 kg of 45 per cent highly enriched uranium (U-235) annually. Since the United States stopped sales of enriched uranium to South Africa in 1975, domestic enrichment has been developed. A second research reactor, the domestically designed SAFARI-II, went into operation in 1967 but was decommissioned in the mid-1970s after the United States stopped furnishing nuclear fuel. South Africa also has two 922-megawatt power generation reactors, the

French-supplied Koeberg-I and II, fuelled with 3.25 per cent enriched uranium. These fully safeguarded reactors went into operation in 1984 and 1985, respectively, initially with French fuel. South Africa is currently shifting to domestic sources for fuel.

37. At the Valindaba research part outside Pretoria AEC has established two uranium enrichment facilities. These use a jet nozzle enrichment process, apparently developed in the early 1970s with assistance from German sources. Both use uranium hexafloride gas manufactured at Valindaba. Neither is under international safeguards.

38. The first of these plants, the Valindaba Pilot-Scale enrichment facility, produces 45 per cent enriched U-235 ostensibly to fuel the SAFARI-I reactor. Its output, however, estimated at a maximum of approximately 50 kg annually since 1980-1981, is considerably in excess of the 14 kg required by SAFARI-I. The excess output from the Valindaba Pilot-Scale facility lies at the centre of debates over South Africa's nuclear capability, since this 45 per cent enriched material can be used directly to manufacture nuclear weapons. On 1 February 1990, AEC announced that it was closing this plant for economic reasons. The implications of this closing are discussed below.

39. AEC also operates the Valindaba Commercial-Scale enrichment plant. Although this facility is much larger, capable of generating up to 50,000 kg of 3.25 per cent enriched uranium annually, it has been of less concern. The enriched U-235 it produces, primarily for use in the Koeberg power generation reactors, is not sufficiently pure for use in nuclear weapons. Some analysts maintain, however, that the jet nozzle enrichment process is readily adaptable to achieving higher degrees of enrichment without extensive modification of facilities. 9/ If so, it is feasible that even after closing the Valindaba Pilot-Scale facility, South Africa may retain the potential to produce more weapon-grade uranium.

40. Unlike some nuclear threshold countries, South Africa does not appear to be emphasizing reprocessing of spent nuclear fuel to retrieve plutonium. A hot-cell laboratory has been established at the National Nuclear Reseaarch Centre at Pelindaba, also near Pretoria, to examine spent reactor fuel. 10/ This facility operates under safeguards only when processing foreign-supplied fuel purchased under safeguarded agreements. There is no evidence to indicate that this laboratory is being upgraded into a full-scale reprocessing facility.

C. New developments

1. Meetings between South Africa and the International Atomic Energy Agency

41. After South Africa's statement in September 1987 that it hoped to sign the NPT, diplomatic efforts centred on talks between South African officials and the representatives of the three depository Governments - the Soviet Union, the United Kingdom and the United States. The first round of discussions held at IAEA headquarters at Vienna in August 1988 mostly exposed differences between the two

sides. The South African delegation, led by the Foreign Minister and the Minister of Mineral and Energy Affairs, seemed to be mostly interested in clarifying the costs and benefits of adherence, especially the responsibilities under the IAEA safeguards agreement. 11/

42. These priorities reflect South Africa's long-held anxieties about the NPT. South Africa's main misgivings about the Treaty, as publicly stated, have stressed not military or security factors but commercial aspects. At the General Assembly on 20 May 1968, South Africa explained its fears that IAEA safeguards would be extended to cover uranium mines and ore-processing mills, exposing South African industrial techniques to commercial espionage. In 1970 the Prime Minister told Parliament that his Government was willing to accept safeguards if they did not allow commercial espionage or hinder South African civilian nuclear research. 12/ The discussions in 1988 showed that these considerations had not evaporated.

43. At the next round of talks, in December 1989 at Vienna, South African priorities concentrated on the practical steps entailed in joining the NPT. Both sides expressed satisfaction with the discussions. 13/ Although participants noted that the South African delegation seemed divided between NPT advocates and critics, the mood remained optimistic. 14/ It was also noted, however, that domestic South African disputes over the NPT might have to be resolved first, which could further delay the process. 15/

44. Nevertheless, in September 1990, at the thirty-fourth regular session of the General Conference of IAEA, a written statement by South Africa's Minister for Foreign Affairs was circulated 16/ that reaffirmed South Africa's intentions regarding the NPT and the acceptance of IAEA safeguards on its nuclear facilities. The statement referred to the Government of South Africa's intention "to accede to the Treaty in the context of an equal commitment by the other States in the southern African region" and to commence talks with IAEA in the near future "on concluding a comprehensive safeguards agreement on the country's nuclear facilities". At the closing session of the General Conference, the IAEA Director-General stated that the Agency's secretariat was ready to start negotiations with South Africa without delay.

2. Closing of the Valindaba Pilot-Scale enrichment facility and its implications for South Africa's nuclear-weapons potential

45. Another important sign of possible progress towards South African acceptance of the NPT is the closing of the Valindaba Pilot-Scale enrichment plant on 1 February 1990. This was South Africa's only facility known to be capable of generating fissile material suitable for nuclear explosives. However, its closure does not eliminate concerns regarding South African nuclear-weapons capability altogether, since significant quantities of weapon-grade uranium may have been stockpiled. There is also the distant possibility that the Valindaba Commercial-Scale facility, which is unsafeguarded, could be modified or otherwise employed to produce weapon-grade uranium. The possible re-opening of the Pilot-Scale plant should not be excluded either.

46. Now that it is reasonably certain that South Africa's supply of highly enriched uranium has stopped growing, it is possible to assess its nuclear-weapons capability with greater accuracy than before. Since the last United Nations estimate was made in 1980, it has become increasingly evident that South Africa's nuclear-weapons potential may not be as great as was previously thought. This new, reduced estimate reflects more accurate information about the Valindaba plant operations, recognizes the use of some fissile material for reactor fuelling and provides better information about the possible nuclear-weapons designs. Moreover, so long as the Valindaba Pilot-Scale plant remains closed and no alternative source of highly enriched uranium is developed, South Africa's nuclear-weapons potential will decrease over time.

47. Previous United Nations estimates of South Africa's stockpile of fissile material assumed that Valindaba had been producing 50 kg of highly enriched U-235 annually since 1977, and that 15 to 25 kg was sufficient for a critical mass. 17/ Carried through to January 1990, this would lead to the conclusion that South Africa has enough fissile material to manufacture 26 to 43 nuclear weapons. This possibly exaggerates South African capabilities by overestimating production of enriched uranium and by underestimating both consumption of fuel by the SAFARI-I reactor and the quantity needed for a critical mass in a weapon.

48. The Valindaba Pilot-Scale plant is generally understood to have started enrichment operations in 1977, apparently for experimental test runs and calibration. Although it was commissioned the following year, it did not achieve maximum operating levels immediately. As late as 1980 Valindaba was unable to provide the SAFARI-I reactor with a full load of 14 kg of 45 per cent enriched U-235. The reactor often ran at a power level as low as 5 megawatts instead of its designed 20 megawatts, apparently to conserve the last of its fuel supplied by the United States. 18/ Accumulation of surplus enriched uranium probably began soon thereafter. If Valindaba reached a peak annual output of about 50 kg 45 per cent enriched uranium, a surplus of as much as 36 kg could have been accumulated each year after allowing for the needs of SAFARI-I. It has been argued, however, that maximum operating levels probably cannot be sustained continuously, in which case the surplus stockpile would accumulate more slowly. 19/

49. Assuming that peak operating levels were maintained continuously, from January 1981 through January 1990, Valindaba could have produced a total of approximately 450 kg of 45 per cent enriched uranium. Of this, 126 kg would be needed to operate SAFARI-I, leaving a stockpile of as much as 324 kg when the plant closed.

50. The number of nuclear weapons that can be fabricated from a quantity of uranium depends upon its level of enrichment. A critical mass of 100 per cent enriched uranium-235 surrounded by a "temper" (a material used mainly to reflect the neutrons that would otherwise have escaped from the assembly) would weigh about 15 kg. With 45 per cent enriched U-235, however, the level produced by Valindaba, a critical mass would require about 55 kg, plus a 10 cm-thick blanket of beryllium as a temper or neutron reflector. If beryllium is unavailable and U-238 must be used as a temper instead, the critical mass of U-235 rises to 90 kg. 20/ Although the size of this critical mass could be reduced by enrichment to higher levels of

purity, the number of critical masses that could be produced would remain the same. 21/ It should be noted that generally U-235 is not a preferred fissile material for fission weapons.

51. With a maximum stockpile of 324 kg of 45 per cent enriched U-235 and access to beryllium metal, a total of approximately five or six nuclear weapons could be assembled. While undoubtedly quite alarming, this is fewer than the 26 to 43 suggested previously. This total will decrease over time as the stockpile is drawn down to fuel the SAFARI-I reactor. Its annual requirement of 14 kg amounts to roughly one quarter of a critical mass per year. Thus South Africa's nuclear potential will diminish until SAFARI-I is decommissioned or alternative supplies of fuel are found.

52. The relatively large amount of 45 per cent enriched U-235 required to create a nuclear weapon also suggests that South Africa, despite its intentions, may not have been in a position technically to acquire a nuclear-weapons capability as early as in 1980 or before, as had originally been assumed. It also suggests that fissile material from Valindaba could not have been involved in the 1977 Kalahari test site and 1979 South Atlantic flash incidents. If these were South African nuclear-test efforts, the fissile materials almost certainly came from another, still unknown source.

53. While the Pilot-Scale plant was closed on 1 February 1990, the Valindaba Commercial-Scale uranium enrichment plant has achieved full operation. It was announced in April 1990 that the plant had provided fuel for one of the Koeberg power-generation reactors. 22/ The 3.25 per cent-low-enriched uranium cannot be used directly for nuclear weapons. There is grounds for concern, however, that the same facility could be modified through the addition of more enrichment stages or that it could be equipped for recycling low-enriched uranium to produce weapon-grade material. These concerns are related to the fact that the facility is not safeguarded.

54. South African uranium production peaked in 1980-1981 when it accounted for 14 per cent of the world total. Since then there has been a marked decline in the country's uranium mining industry. Sanctions on trade with the white minority Government and the general decline of the global nuclear power industry have greatly reduced demand. In 1989 South Africa supplied only 8 per cent of total world uranium supplies. The market situation is reflected in the closure in 1989 of 4 out of 11 remaining uranium mines operating in South Africa. 23/ Moreover, following the Namibian independence in November 1989, South Africa lost control of the highly profitable Roessing mine, which it developed in the mid-1970s, producing earnings of over $US 350 million annually by the mid-1980s. 24/ The lost income will make it harder for South Africa to finance its nuclear programme.

55. Although the United Nations embargo and international sanctions have virtually eliminated South Africa's ability to acquire major nuclear technologies, smaller items and know-how continue to reach the country. A fuel-fabrication measurement device was transferred illegally by a firm from the Federal Republic of Germany. The United States discovered that its Department of Energy had, through lax security procedures, given information on detonators and explosives with possible nuclear applications to citizens of several nuclear threshold States, including South Africa. 25/

D. Accession to the Treaty on the Non-Proliferation of Nuclear Weapons and its impact on South African nuclear capabilities

56. Of the several threshold nuclear States outside the NPT, South Africa has emerged as the one most likely to accede to the Treaty. Meetings at IAEA at Vienna and particularly the closing of the Valindaba Pilot-Scale enrichment facility have fostered expectations that South Africa may do this soon. The momentum towards NPT accession also reflects the fact that South Africa has been uniquely subjected to United Nations action. Unlike any other State, it has been viorously condemned, isolated from the international community and subject to rigorous trade sanctions and arms embargoes, all with the express goal of bringing an end to apartheid, regional intervention and the pursuit of nuclear-weapon capabilities.

57. The balance of incentives that previously made nuclear capability an alluring option to some has changed dramatically since late 1988. Motives have always been the weakest aspect of a possible South African nuclear-weapon programme. Lacking nearby adversaries capable of launching major conventional attacks on their territory, South African nuclear weapon advocates have had to justify the nuclear-weapon option on a supposed need to deter global adversaries, especially the Soviet Union. Such arguments have never been convincing, however. Now that the "communist ideology", which officials in South Africa used to cite as a threat to the country's survival, is no longer a major issue in East/West relations, nuclear-weapon advocates are hard pressed to justify maintenance of nuclear options. 26/

58. As the possible motives for nuclear options diminish, the costs of maintaining that option have risen. International trade sanctions and changing market conditions have undermined the policy of financing nuclear development through uranium exports. The nuclear programme increasingly must compete with other priorities in the national budget. On the other hand, this could change if South Africa acceded to the NPT and the concomitant safeguards agreement. South African uranium exports could be expected to rise under international safeguards. 27/ Acceptance of full-scope safeguards would also ease expansion of South Africa's civilian nuclear power generation reactors by easing access to foreign technology, under article IV of the NPT. South Africa would also have greater access to international measures and programmes to improve reactor safety.

59. Accession to the NPT by South Africa would also remove the single main obstacle to the effective establishment of an African nuclear-weapon-free zone, since no other African State has a comparable nuclear programme. It is widely anticipated that South African accession to the NPT would create a favourable condition for other regional hold-outs to sign as well. Their ranks include Algeria, Angola, Djibouti, Mauritania, Mozambique, Niger, the United Republic of Tanzania, Zambia and Zimbabwe. In this way, joining the NPT would greatly strengthen South Africa's place in the international community and reinforce the Treaty.

60. It should be pointed out, however, that signing the NPT and safeguards agreement cannot, in and of themselves, eliminate fears of South Africa's nuclear capability. The possibility will remain that unsafeguarded weapon-grade uranium has been stockpiled secretly. South African leaders could also opt to withdraw

from the Treaty (under art. X) and immediately apply their large nuclear infrastructure to weapons fabrication. 28/

61. Long-term assurances of peaceful intentions can only be provided through domestic political transformation. Regional leaders have long maintained that it is apartheid rule and the grave insecurity it generates for South Africa that most severely aggravate regional instability. While the acceptance of the NPT will significantly reduce regional tensions, it is continued political change within South Africa that will end fears of its nuclear capability most completely.

Notes

1/ Report of the Ad Hoc Panel Convened by the Office of Science and Technology Policy of the Executive Office of the President of the United States of America on the 22 September Event, contained in the report of the Secretary-General on the inquiry into the reports concerning a nuclear explosion by South Africa (A/35/358).

Another report by the United States Naval Research Laboratory reportedly came to an opposite conclusion, that the flash probably was a nuclear explosion. This report formed the basis for a press release by United States Congressman John Conyers, "New Evidence on South Africa's Nuclear Explosion", Washington, D.C., 21 May 1985.

2/ South Africa's plan and capability in the nuclear field (United Nations publication, Sales No. E.81.I.10), paras. 45 and 51.

3/ Special Committee Against Apartheid, The Development of South Africa's Nuclear Capability (A/AC.115/L.602); and the report prepared by the United Nations Institute for Disarmament Research on South Africa's nuclear capability (A/39/470, annex).

4/ The United Nations Disarmament Yearbook, Volume 13, 1988, pp. 241-247.

5/ Leonard S. Spector, The Undeclared Bomb, Cambridge, Massachusetts; Ballinger, 1988, pp. 290-296.

6/ The diplomatic background is recorded in IAEA General Conference, Report by the Board of Governors, South Africa's Nuclear Capabilities (GC(XXXI)/807).

7/ Ann MacLachlan and Gamini Seneviratne, "South Africa Hints NPT Signature, Averts IAEA Suspension Threat", Nucleonics Week, 23 September 1987.

8/ Robert M. Lawrence and Joel Larus, Nuclear Proliferation Phase II, Lawrence, Kansas, Allen Press, 1974.

9/ Alan S. Krass, et al., Uranium Enrichment and Nuclear Proliferation, London, Taylor and Francis for SIPRI, 1983, pp. 136-146.

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10/ Report of the Secretary-General on South Africa's nuclear capability (A/39/470), chap. V.

11/ Discussions with the Ambassadors of the three Depository Governments of the NPT, 17 April 1990, Vienna.

12/ George Barrie, "South Africa", in Jozef Goldblat, ed., Non-Proliferation: the Why and Wherefore, London, Taylor and Francis for SIPRI, 1985, pp. 151-160.

13/ "Discusses Vienna Talks", Johannesburg Television Service, 12 December 1989; and "Notes 'Progress'", Johannesburg Domestic Service, 13 December 1989, in JPRS-TND, 4 January 1990, pp. 1 and 2.

14/ Paul Lewis, "South Africa Seen as Ready to Sign Nuclear Pact", The New York Times, 21 March 1990, p. 11; and Holly Porteous, "France, South Africa May Join NPT", Jane's Defence Weekly, 21 July 1990, p. 78.

15/ The Arms Control Reporter, sect. 455.B.39-40, see event dated 2 April 1990.

16/ GC(XXXIV)/INF/290 of 19 September 1990.

17/ South Africa's plan and capability in the nuclear field, op cit., para. 45.

18/ Caryle Murphy, "South Africa Powers Reactor with Uranium it Enriched", The Washington Post, 30 April 1981.

19/ Spector, The Undeclared Bomb, op. cit., p. 293.

20/ Alexander De Volpi, Proliferation, Plutonium and Policy: Institutional and Technological Impediments to Nuclear Weapons Propagation, New York, Pergamon, 1979, appendix A, "Critical Mass Curves". All figures for critical mass are estimates within plus or minus 10 per cent.

21/ Reducing the size of the critical mass to the minimum of 15-25 kg might still be of value, even if it produces no additional weapons, by reducing the problems of weapons design. It also would facilitate greater explosive yields.

22/ "Local Manufacture of Nuclear Fuel Revealed", Cape Times, Cape Town, 25 April 1990, p. 3, in JPRS-TND, 12 June 1990, p. 3.

23/ NUEXCO 1989 Annual Review.

24/ Report of the Secretary-General on South Africa's nuclear capability, op. cit., para. 19 and chap. VII, sect. B.

Notes (continued)

25/ Harald Mueller and Richard Kokoski, The Non-Proliferation Treaty: Political and Technological Prospects and Dangers in 1990, Stockholm, April 1990, p. 13 (SIPRI research paper).

26/ David Fischer, "South Africa: An Opportunity for Western Europe", in Peter Lomas and Harald Mueller, eds., Western Europe and the Future of the Nuclear Non-Proliferation Treaty, Brussels, Centre for European Policy Studies, 1989, pp. 85-92.

27/ Jozef Goldblat, Twenty Years of the Non-Proliferation Treaty: Implementation and Prospects, Oslo, Peace Research Institute, 1990, p. 14.

28/ Spector, The Undeclared Bomb, op. cit., p. 300.

IV. SOUTH AFRICA'S LONG-RANGE MISSILE PROGRAMME

A. General observations

62. In recent years there has been an acceleration of the diffusion of modern technology associated with warfare to various regions of the world. This is especially the case with respect to nuclear and ballistic missile technology. Depending on the source used, typical estimates will indicate 15 or more States acquiring ballistic missile capability by the end of the decade, while 14 others already have chemical weapons and 9 have a nuclear weapon capability. 1/ This trend has global implications and is not unique to any particular region.

63. Ballistic missiles are seen primarily as nuclear weapon delivery vehicles. Generally speaking ballistic missiles as such are not accurate enough to justify their cost carrying conventional warheads. There is thus a strong and not erroneous presumption that their acquisition by States that are known also to be acquiring a nuclear weapon capability (and/or other mass destruction weapons) is for the eventual linking of the two.

64. The impact of ballistic missiles on deterrence or existing balances is dependent most of all on the context and on the military doctrine of the possessor. Launchers if married to warheads of mass destruction (chemical warfare or nuclear) could be intended by the acquiring State as strategic weapons and for deterrence. Such States may consider these weapons as a legitimate counter to an adversary's nuclear weapons and see threats to use them in self-defence as permissible. Certainly this will pose problems as to clarifying the precise intended function of the new weapons, including what they are intended to deter.

65. Although South Africa is not the only possible place for the use of missile technology married to nuclear weapons or other weapons of mass destruction, the repugnant nature of the apartheid system has prompted a strong concern about the effects the acquisition and development of such technology would have for the security of southern Africa and on the prospects for the establishment of a nuclear-weapon-free zone in that region.

B. Background

66. South Africa has been developing rockets and missiles since the mid-1960s. Most of these efforts have concentrated on several short-range, tactical missiles for battlefield use. 2/ However, only two of the missile projects developed by the Armaments Corporation of South Africa (ARMSCOR), have entered production and serve in the South African Defence Forces (SADF): the 22-km-range Valkiri surface-to-surface artillery rocket, and the V3 Kukri air-to-air missile with a range of 4-10 km. Both systems were introduced in the early 1980s. Since then, Kentron, the ARMSCOR subsidiary specializing in missile development and production, reportedly has made its anti-tank, surface-to-air missiles and anti-ship missile programmes a priority. The anti-ship missile project is the largest and most sophisticated of the three. It would provide experience with an intermediate

technology towards development of long-range missiles. However, the available supporting evidence of such work is still inconclusive.

67. Through its civilian rocket research and military developments, South Africa has built up a thorough infrastructure for the design and production of small, tactical missiles. It has also accumulated many of the skills and resources needed to undertake a long-range missile programme, although it lacks crucial scientific and industrial experience essential to domestic development and manufacture of long-range missiles. At present such an undertaking would be possible only with substantial foreign technical assistance. (South Africa's previous military-industrial and missile production experience is examined at greater length in appendix I.)

C. Long-range missile manufacturing potential

68. Despite the weaknesses of the rocket and missile industry, reports of ARMSCOR and the SADF efforts to acquire long-range missiles have circulated for over a decade, culminating in South Africa's announcement that it had test-fired a "booster rocket" on 5 July 1989. Most press reports and academic assessments of South African interest in long-range missiles emphasize the possibility of technical collaboration with Israel and/or Taiwan, Province of China. The possibility of an indigenous project led by ARMSCOR cannot be excluded, however, until thorough official disclosure about the South African long-range rocket programme is made.

1. Technical capabilities

69. Some of the earliest reports of South African interest in long-range missiles focused not on ballistic missiles but rather on cruise missiles. In 1971 the South African Aeronautics Research Unit announced that it was developing a valveless pulse-jet engine. 3/ Pulse jets, used to power the German V-1 "Buzz Bomb" of the Second World War, are low-cost engines, especially simple to manufacture. They are poorly suited to powering manned aircraft owing to their lack of flexible control and very short service lives (only a few hours). These same characteristics make them more suitable for unmanned cruise missiles, which fly predetermined flight paths and are only used once.

70. Nothing more has been reported regarding the South African pulse-jet engine, but reports of cruise missile projects persist. South African participation in cruise missile projects with Israel and Taiwan was the subject of unsubstantiated reports in the early 1980s. 4/ These reports seem to refer to procurement of anti-ship missiles in South Africa and Taiwan, Province of China, virtually identical in appearance to Israel's Gabriel-II. One report referred to a cruise missile with a range of 3,000 km, although none of these countries tested a weapon in that class during the decade. 5/ As recently as 1986, the Chairman of ARMSCOR stated that South Africa was developing an advanced gas-turbine engine, which he called a tremendous technological breakthrough that could be used to propel long-range cruise missiles. 6/

71. The only other direct evidence of long-range missile development was the establishment of a new missile test range. In March 1983 the Government announced that the Saint Lucia test range would be closed, ostensibly because its proximity to Mozambique made secure testing of long-range weapons difficult. The Cabinet subsequently approved construction of a new test site at Overberg, east of Cape Town. Situated over the De Hoop Nature Reserve, the new range aroused public controversy and debate, leading to the appointment of the Hey Committee, which concluded that the site was vital to the country's interests. Construction and instrumentalization for the new range was estimated to cost R 238 million, with completion scheduled for 1990. 7/ ARMSCOR also established a new subsidiary adjacent to the test range near the town of Houwhoek, employing a staff of 400 (75 per cent engineers and scientists) to support missile tests. 8/ The 5 July 1989 rocket launch used the Overberg site.

72. Attention also has been drawn to a new airfield and facilities - Marion Island - in the Antarctic constructed in the mid-1980s at a cost of $US 5.8 million. Located 1,900 km south of Cape Town, the Marion Island base was justified by the South African Department of Environmental Affairs as a civilian installation for meteorology, fisheries management and emergency landings. Some scholars have argued that the site is suitable for testing missiles, including nuclear missiles, although there has been no additional evidence to support this claim. 9/

2. Technical hurdles

73. While the intentions and test facilities for a long-range missile project may exist in South Africa, domestic development and production of a missile requires a large spectrum of technologies and human skills. Few of these are known to be present. South Africa has little if any experience with technologies such as high-thrust engines and propellant fabrication, inertial guidance platforms for ballistic flight, as well as re-entry vehicles capable of withstanding very high temperatures.

74. Overcoming these technical hurdles will most likely require considerable time. The successful development of an intermediate-range ballistic missile (IRBM) or space-launch vehicle (SLV) is usually a lengthy process. Major missile and rocket programmes typically take 10 to 15 years to enter production. The development of sophisticated weapons requires a knowledge gained from first working on smaller, less sophisticated weapons. Countries receiving large-scale technical assistance can, however, accelerate or bypass some stages.

3. Financial hurdles

75. Financial considerations are also important. Although long-range rocket and missile technology developed during the 1940s and 1950s remains entirely adequate for most countries developing their own systems today, the cost of such technology is not low. Full-scale development of a ballistic missile currently costs about the same as development of a fighter aircraft. For the Hades, a modern short-range

missile, France is investing some FF 14 billion ($US 2.3 billion). 10/ South Africa would have to plan for similar investments to complete a long-range missile programme of its own.

D. The role of Israel

76. Military co-operation between South Africa and Israel can be traced back to the 1950s. Originally confined to small arms, second-hand weapons and military assistance, Israeli arms transfers grew significantly in the late 1970s as other suppliers - especially those in Western Europe - began to heed the 1963 and 1977 United Nations embargoes. As part of a large bilateral trade relationship, Israel furnished South Africa with small naval vessels, air-to-air and anti-ship missiles and technical assistance. 11/ The latter has become increasingly important since the early 1980s. As ARMSCOR's industrial capability matured, South Africa increasingly sought not finished armaments, but components and technical assistance to facilitate its own domestic military research and development.

77. The 1980 United Nations study on South African nuclear capability observed that "South Africa's leaders now appear to be turning in part to ties with other so-called 'garrison States' similarly suffering from varying degrees of international isolation". The study notes that this relationship appeared to extend into the nuclear realm, and that South Africa "could covertly stockpile weapons and rely, much as Israel is thought ... to have done, on unconfirmed ... rumours that it had those weapons in order to further its purposes". It also argued that South Africa might exacerbate the horizontal proliferation of nuclear weapons by co-operating with other States with similar ambitions. 12/

78. Evidence for Israeli-South African co-operation on long-range missiles would be consistent with this general pattern. The evidence, however, still remains largely circumstantial. Reports of South African co-operation with Israel in the development of missile technology come from media sources, often based on unattributed disclosures from "government officials".

79. After 1985, as evidence emerged that Israel was developing an improved ballistic missile generally known as the Jericho-II, analysts focused on the possibility that this technology could be supplied to South Africa. One scholar argued that "reports that Israel has deployed 20 Jericho-II nuclear missiles in the Negev Desert suggest that South Africa's own Jericho missiles would be a suitable delivery system for more lethal weapons". Another regional specialist noted that "there are unconfirmed reports that Israel has provided South Africa with the Jericho ballistic missile, but there is no verifiable evidence to substantiate this claim. More likely, Israel may be providing South Africa with assistance in developing sophisticated missile components such as guidance systems". 13/

80. In January 1989, the United States received what was described as a reliable intelligence report that Israel was aiding South Africa's IRBM programme. The United States, through its Ambassador to Israel, reportedly delivered a series of official protests. These were, however, rejected by the Government of Israel. 14/

81. In June 1989, United States intelligence sources picked up evidence of an imminent test at Overberg. Satellite photographs reportedly showed a test site identical to an Israeli site used to launch the Shavit space launch vehicle, a modified version of the Jericho-II. 15/ Unable to conceal the test, South African authorities announced the successful launch on 5 July, describing it ambiguously as a "booster rocket". The description probably refers to the design of the Shavit as a space launch vehicle, although in this case it was fired in a ballistic arc, falling into the sea near the Prince Edward Islands some 1,450 km to the south. Some reports claimed that the missile was a smaller, modified version of the Jericho-II ballistic missile. Later descriptions also referred to the rocket as the Irah-3 or the Arniston. 16/

82. Little data has been released about the Israeli rockets. The ballistic missile generally known as the Jericho-II (its Israeli designation is unknown) has been referred to since 1985. It has been described as a two-stage, solid-fuel rocket with an inertial guidance system. With a maximum payload of 1,000-1,500 kg, it almost certainly can carry a nuclear weapon; most studies and reports assume that the Jericho-II is intended for this role. Although initial press reports suggested it was deployed in the early-1980s, long-range tests appear to have started in 1986. In the longest test flight so far, the Jericho-II travelled 1,300 km on 14 September 1989. The Jericho-II is widely reported to have a maximum range of 1,450 km. 17/

83. The Shavit space launcher, a three-stage development of the Jericho-II, first flew on 19 September 1988, launching the Ofeq-1 satellite into orbit. The 156 kg satellite was launched into a retrograde orbit (against the spin of the Earth and requiring a more powerful rocket than for a normal launch with the planet's spin) at an altitude of 248 to 1,147 km. The Shavit has been analysed at the Lawrence Livermore National Laboratory in California. Using the known orbital parameters of the satellite released during the Shavit's first launch and orthodox assumptions about the rocket's characteristics, it was concluded that the Israeli SLV could be reconfigured as a ballistic missile capable of delivering a 500 kg warhead to a range of 7,500 km, which would make it an ICBM. 18/ Whether the missile launched by South Africa was of comparable size is not known.

84. In October 1989, world attention was once again drawn to South Africa's ballistic missile programme. The media reported what appeared to be a confirmation by the United States Government that Israel had furnished the Shavit rocket to South Africa. 19/ The Washington Post, for example, reported that the deal involved a swap - the rocket for uranium. United States officials subsequently pointed out that the evidence was not incontrovertible. One official cautioned that "we don't have any evidence that it is a plain uranium-for-missiles deal. Think of the relationship as a whole series of deals". 20/

85. The official South African response to the allegations was limited to a statement by the Minister for Foreign Affairs that "The Minister bears no knowledge of such co-operation", while a Department of Defence spokesman denied the reports, saying that the aim of South African arms research was to advance its own technology. Israeli officials responded in much stronger terms. The Defence Minister said that "This report is totally untrue; it is a completely unfounded story. In simple words, it is simply almost a lie - not almost, but a lie". 21/

86. In this connection, Israeli officials also recalled the declaration of the Israeli Cabinet of 18 March 1987 that Israel would not conclude any new military agreements with the white South African Government. The declaration was understood at the time to exclude previously concluded arrangements. The United States Assistant Secretary of State for African Affairs stated that the long-range rocket arrangement appeared to date from before the 1987 declaration: "I am assuming that any co-operation on an intermediate-range ballistic missile comes under existing contracts". 22/ Perhaps the most important consequence of the United States-Israel controversy has been the unwillingness of the former to license a proposed transfer of a Cray-2 supercomputer - suitable for designing nuclear weapons or ballistic missiles - to Israeli's Technion University. The controversy failed, however, to clarify exactly what South Africa may have received from Israel. 23/

87. The rocket launched on 5 July 1989 almost certainly was based on foreign technology. However, little is known about the weapon. While Israel has the know-how to have helped to develop such a rocket, the weapon's design is not known. Several other countries also possess, and are known to have exported, such technology. The extent to which the rocket's components were of domestic origin is also unknown as is South Africa's level of participation in the rocket's production. The weapon may have represented little more than a modified rocket already in South Africa's inventory. No information exists on whether or not South Africa possesses further examples. Finally, assuming that the rocket was of foreign design and not a modification of an existing weapon, it is not known if South Africa has entered into a licensing or co-production agreement with the weapon's manufacturer to produce the weapon in its entirety or any number of critical components.

88. Assuming South Africa received only a single rocket with technical data and plans, ARMSCOR has an important model to guide its own missile research and development work, easing the problems of full-scale development significantly. With a clear model of a complete missile in hand, development could be shortened by several years. Development of domestically manufactured long-range missiles still could be expected to last about 10 years, but many intermediate steps and false paths could be avoided. With detailed production licences, manufacturing assistance and imports of major components, the process probably could be reduced to five years or less, depending upon the degree of national commitment.

E. Motives and incentives for long-range missile acquisition

89. South African willingness to accept the costs and challenges of building up its long-range missile or rocket capabilities will depend upon the goals motivating the programme. These factors fall into three general categories: military requirements, commercial and diplomatic incentives, and space launch. Behind all of these factors stand the need for symbols of power and the prestige of advanced technology, intangible motives whose importance should never be underestimated.

90. The role of specific motives can change over time. The importance of military requirements for long-range ballistic missiles, for example, might diminish and yield to a greater emphasis on civilian space launch capability, or commercial

incentives could justify accumulation of technical expertise later applied to meeting military needs. The situation is clouded since some evidence can be found for all three general categories of motives simultaneously. Yet these motives are of overwhelming importance to the future of the South African programme. Some arise from particular concerns of the white minority Government in the mid-1980s and may diminish as progress is made toward majority rule. Others reflect priorities found among countries in all regions of the world and may lead future South African majority-rule Governments to keep elements of the long-range rocket programme initiated by the predecessors.

1. Military requirements

91. Civilian and military leaders of the white minority Government perceived the ability of the South African Air Force (SAAF) to attack targets far from South African borders as an important element of its military power. But the Air Force fleet of fighter aircraft is shrinking as a result of its inability to purchase additional aircraft abroad or manufacture them at home. While accident rates in normal peace-time training have been reduced through rigorous training, they cannot be eliminated. 24/ Military intervention in neighbouring States dramatically increases losses. Moreover, as other countries in the region strengthen their air defences, the ability of SAAF to conduct long-range operations successfully declines further.

92. The declining relative strength of SAAF became increasingly evident during fighting in Angola in 1987-1988, in which SADF relied extensively on their air arm to support forces on the ground. After suffering from SAAF air superiority in the early 1980s, Angola built up its air defence system to include some 140 modern Soviet tactical aircraft (MiG-21, MiG-23 and Su-22). This force outnumbers the SAAF inventory of about 80 advanced fighters obtained from Western sources (Buccaneer, Mirage-III and Mirage F-1). Angola integrated its fighters into an air defence system including dozens of ground radars, 5 battalions of surface-to-air missiles with over 140 launch units, over 300 anti-aircraft guns, many of them radar-controlled. 25/

93. Angola's integrated air defense system greatly reduced SAAF freedom of action in 1987-1988 compared to earlier South African interventions. Angola claimed the destruction of 40 SAAF aircraft during the 1987-1988 fighting. In a typical incident, on 22 February 1988, Angola claimed to have shot down two South African Mirage fighters in fighting near Cuito Cuanavale. South African Defence Forces headquarters admitted losing one of the irreplaceable fighters. 26/ Other Mirage fighters were lost as well. Slower, more vulnerable aircraft such as SAAF's large inventory of Impala fighter/trainers had to be withdrawn from the fighting altogether after suffering unacceptable losses.

94. As the regional dominance of SAAF declines, South African officials have begun to emphasize the need for missiles to maintain the country's military options. In 1985 the Chairman of ARMSCOR suggested that the country would need ballistic missiles with a range of 200 to 300 km to compensate for the approaching shortfall of SAAF strike aircraft. A year later he said that after the Cheetah upgrade

project for Mirage fighters, ARMSCOR's next major project would be missiles able to hit targets in neighbouring countries. In 1988 the chief executive of ARMSCOR told an interviewer that "what we need is medium-range rockets and long-distance artillery". 27/ His comments made no reference to weapons of mass destruction, apparently advocating conventionally armed missiles while leaving other options open.

95. Long-range missiles offer additional advantages over manned aircraft. By landing 1,450 km from its launch point, the rocket tested on 5 July 1989 demonstrated greater reach than any SAAF manned aircraft except for its five remaining Hawker Siddeley Buccaneer bombers, which can reach targets 1,850 km away. 28/ The Buccaneers are approaching the end of their service lives, however. Once that happens, the SAAF inventory of attack aircraft will consist of only Mirage fighters with maximum combat radius of 900 km on attack missions and opening a place in its force structure for missiles with long range.

2. Commercial and diplomatic incentives

96. In addition to producing ballistic missiles for their own use, several countries have transferred missiles abroad, either to support military or diplomatic goals, or to earn foreign exchange. South Africa increasingly seeks export markets for ARMSCOR. Its long-range rocket programme may not be immune from this pressure. Exports could help to subsidize South Africa's investment or could be a separate goal of the programme.

97. The South African long-range rocket programme also may support similar diplomatic purposes by promoting bilateral relations with friendly Governments. South African co-operation with Israel and Taiwan, Province of China, is generally assumed, especially with regard to conventional weapons and nuclear technology. 29/ South Africa can also offer Israel a reliable partnership, greater funding and resources for the programme, and geographical advantages. The latter could have special appeal to Israel, which lacks unrestricted test areas and must test-fire its long-range missiles and rockets in an inefficient north-westerly trajectory across the Mediterranean to minimize provocations to neighbouring States. Use of South Africa's Overberg test range could provide Israel with a significantly less restrictive test environment.

3. Space-launch capability

98. The same type of rocket used to deliver warheads over great distances can be used to launch research payloads and satellites into space. A space-launch vehicle (SLV) is, if anything, technically simpler than an intercontinental or intermediate-range ballistic missile. The SLV does not require a highly accurate internal guidance package since it can function with simpler gyros, accelerometers and commands from the ground. In most cases an SLV does not require a sophisticated re-entry vehicle either. Finally, an SLV need not be as reliable as a ballistic missile since it can be launched on its own schedule under constant supervision. Any country capable of building a long-range ballistic missile is also capable of launching a space satellite. 30/

99. South African officials made no attempt to justify the 5 July 1989 test flight as part of a space-launch programme. Yet there is discussion within South Africa of upgrading the national space research programme to include launch activities. The "booster rocket" technology currently in possession could provide the basis for an effective SLV.

100. South African participation in space research dates to the late 1950s. The tracking station at Hartebeeshoek, built with equipment and assistance from France, has supported satellites and space exploration by France and the United States. The country also utilizes the satellite facilities of Intelsat, in which South Africa owns stock. This activity has produced a cadre of skilled personnel and an incipient "space lobby".

101. In March 1988, the Minister for Economic Affairs and Technology announced that the Council for Scientific and Industrial Research (CSIR) had been commissioned to undertake a feasibility study for a "totally South African" space programme. 31/ Also participating were the Department of Trade and Industry, the Department of Posts and Telecommunications, the Industrial Development Corporation, the South African Broadcasting Corporation, the Weather Bureau and the country's academic space research community.

102. When the study findings were made public in September 1989, CSIR concluded that South African industry is capable of supporting an advanced space programme of its own, but that it was too expensive to develop an indigenous launch system at present, especially after considering the glut of excess satellite-launching capability world wide. Instead the study urged greater investment in space-related activities, especially communications, data transmission, navigation, weather prediction and other civil applications. 32/ The study effectively halted action towards development of an SLV, but the option remains open since the technology base is in place.

103. A space-launch capability also could be used to military ends by orbiting reconnaissance and intelligence satellites. Although the complete infrastructure required to launch and maintain a dedicated military reconnaissance image satellite may require an investment of several billion dollars, countries in Europe and the Middle East appear to be taking steps in this direction. 33/ South Africa has reportedly shown interest in developing a spy satellite of its own, although there is no clear evidence of large-scale investments yet. 34/

F. Military alternatives to ballistic missiles

104. The 5 July 1989 rocket test heightened international concern that South Africa is developing long-range ballistic missiles. The prospect is alarming largely because ballistic missiles, more than any other delivery system, are linked, in the opinion of casual observers and military professionals alike, with weapons of mass destruction. Yet alarm over the possibility of the white minority Government acquiring long-range ballistic missiles should not obscure the fact that other delivery vehicles can be used with weapons of mass destruction. Although some of these alternative delivery systems seemingly are commonplace and mundane, they can be just as deadly in many circumstances.

1. Manned aircraft

105. Despite the eroding capabilities of SAAF, manned aircraft will remain the primary candidate for delivery of weapons of mass destruction in the foreseeable future. 35/ Even if ballistic missiles can be acquired within 5 to 10 years, it will be longer before enough missiles and operating experience are accumulated to rely upon them. Correspondingly, even without ballistic missiles, South Africa will be able to deliver weapons of mass destruction to targets throughout the region.

106. Indeed, manned aircraft have certain advantages that could convince decision makers to retain them as long-range delivery systems even after long-range missiles become fully operational. Manned aircraft can be recalled in flight, redirected and are re-usable. They also have greater tactical flexibility and can carry any of a large variety of weapons.

107. South Africa appears to be developing a new tactical aircraft of its own design. The design currently under development reportedly will not involve major technological breakthroughs, but is tailored to South African military requirements and economic restrictions, relying extensively on existing Mirage-III technology. Some 75 Israeli engineers previously involved in Israel's highly advanced Lavi fighter project are believed to be working on the South African design. If pursued to completion, such an undertaking will still cost several billion United States dollars. The aircraft could fly in 8 to 10 years, permitting operational capability soon after the year 2000. Whether or not the development programme will continue has not been made clear.

2. Aerial refuelling

108. One of the shortcomings of manned aircraft is their limited range. This can be overcome through aerial refuelling, a capability that South Africa is developing. 36/ In the mid-1980s SAAF converted its four French-supplied Boeing-707 transport aircraft into aerial refuelling tankers/electronic intelligence platforms. 37/ Its remaining five Buccaneer bombers were already equipped for aerial refuelling. The Cheetah conversion programme for the SAAF's 42 Mirage-III fighters is equipping those aircraft for in-flight refuelling as well. With aerial refuelling, SAAF will be a more flexible and versatile force, capable of reaching targets as far as 2,000 km away. This may reduce interest in acquiring ballistic missiles.

3. Artillery

109. Some analysts view South Africa's large-calibre artillery, for example, the 155 mm G-5 towed and G-6 self-propelled howitzers, developed in the 1970s as potential delivery systems for nuclear weapons. It has been suggested that the 1979 South Atlantic flash came from a test detonation of a nuclear device suitable for artillery delivery. No new evidence on this question has emerged since it was examined by the United Nations in 1983.

110. The question of nuclear-capable artillery, however, is largely separate from that of long-range rockets. While long-range missiles are designed to attack strategic targets hundreds or thousands of kilometers away, the range of artillery is limited to the immediate battlefield, typically no more than 30 km, although this can be raised with the use of rocket-assisted projectiles such as the 155 mm shell developed by Space Research Corporation of Belgium and Canada (SRC) for South Africa to about 38 km. 38/ Only under special conditions can artillery substitute for long-range ballistic missiles, while the ballistic missile almost always can substitute for artillery.

G. Arming long-range missiles

111. The arming of a long-range missile is a complicated question deserving special scrutiny. Although press reports of the 5 July 1989 rocket test often referred to a "nuclear-capable" or "nuclear-tipped" missile, long-range missiles can be armed with conventional or chemical and biological weapons as well. Moreover, the early-generation nuclear devices that can be created by a threshold nuclear-weapon State are unlikely to be suitable for missile delivery. Historical experience is not a clear guide either. While the five nuclear-weapon States deploy over 20,000 nuclear armed missiles, they often field identical missiles with conventional warheads and store chemical warheads for some. Since South Africa has not tested or deployed armed long-range missiles, the options presented here are necessarily hypothetical.

1. Conventional armament

112. Most conventionally armed missiles deployed today are systems with ranges under 500 km. A few cases exist of longer-range missiles with conventional warheads, but most of these were developed in the 1940s and 1950s before small nuclear warheads became available. More recently, in the late 1980s, some Middle Eastern countries began to acquire conventionally armed long-range missiles.

113. At long ranges most missiles lack sufficient accuracy to be militarily effective with conventional warheads. Conventional arming of a missile based on the 1,450 km range rocket tested on 5 July 1989 would be militarily senseless, except as a temporary expedient. Only short-range missiles (with ranges under 500 km) can be acquired in quantities of hundreds or thousands, enough to produce tremendous destruction with conventional explosives.

114. The impact of a conventional warhead can be increased with cluster munitions of the sort that ARMSCOR currently produces for its 450 kg aerial cluster bomb. First tested in 1985, this weapon releases hundreds of small anti-personnel munitions to blanket an area of several hectares. 39/ Another option is fuel-air explosives, which rely on the detonation of an aerosol cloud over the target area to achieve tremendous blast effects. 40/ Doubts remain about whether fuel-air explosives can be delivered by high-speed delivery vehicles such as ballistic missiles. They may be more appropriate for use with cruise missiles. A final conventional option is independently guided sub-munitions. These theoretically

would enable a single missile to destroy targets like an entire tank company. Such SDI technology, however, probably lies far beyond the manufacturing capability of a country like South Africa.

2. Chemical weapons

115. Standing midway between conventional and nuclear weapons in terms of destructiveness, chemical weapons (CW) are widely thought to be technically feasible for most countries with an established chemical industry. There are major uncertainties, however, about the ability of ballistic missiles to deliver CW effectively, especially missiles with ranges over 500 km. These missiles travel through space and reach their targets at great velocity, posing enormous difficulties for releasing and dispersing fluid agents. Indeed, while chemical warheads have been developed for ballistic missiles, there is no experience of their use in war. 41/ Even in the Iran-Iraq war, where hundreds of ballistic missiles were launched, chemical weapons were delivered exclusively by artillery and aircraft. 42/

116. South Africa has been a party to the 1925 Geneva Protocol on Chemical Weapons since 1930, but like many other parties it reserves the right to use chemical weapons against States not party to the Protocol and in retaliation against violators. There have been reports of South African production and use of chemical weapons, but most of them are too vague to be substantiated, specifying neither the chemical agent involved nor its effects. The exceptions are CS riot control gas, routinely used to enforce domestic security, and chemical defoliants the use of which in Namibia, southern Angola, and possibly Mozambique has been confirmed by the Government of South Africa. 43/ There is no evidence of South African production or deployment of lethal CW, including those agents best suited for missile delivery such as VX.

3. Nuclear weapons

117. Having fissile material and the ability to fabricate nuclear weapons does not automatically equal the ability to manufacture nuclear warheads for missile delivery. Designs must be perfected, greatly reduced in size and equipped with special fusing and re-entry components. This is a costly and time-consuming process for any nuclear Power. The first generation of United States nuclear weapons, for example, weighed 4,500 kg, far too large for missile delivery. This figure must be reduced to approximately 500-750 kg for delivery by long-range missiles, unless the threshold State is prepared to build extremely large missiles. 44/ Reducing the size of the nuclear device tends to result in a less robust design, more likely to malfunction. Consequently, its development requires either test detonations or sophisticated computer simulations.

118. Unlike a gravity bomb or a cruise missile, the nuclear weapon delivered by ballistic missile requires a protective re-entry vehicle to return through the atmosphere without being destroyed or sacrificing accuracy. Designing re-entry vehicles is an art in and of itself, requiring advanced testing facilities. The

shock and heat of re-entry also require advanced materials for heat-shielding. Finally, the missile-delivered nuclear warhead requires complicated fusing if it is to detonate predictably.

119. It can be concluded that once a country acquires its first nuclear weapon, several years of expensive work must be completed to adapt that weapon for long-range missile delivery. The available evidence is not sufficient to determine what, if anything, South Africa is doing in this regard. While South Africa is widely understood to be nuclear-capable and probably has enough fissile material for a small number of nuclear weapons, nothing is known about its capabilities regarding the design of sophisticated nuclear weapons or re-entry vehicles. 45/

4. Thermonuclear weapons

120. Because of the general inaccuracies of long-range ballistic missiles, even fusion nuclear weapons with explosive yields in the kiloton range (such as the bomb dropped on Hiroshima, with an explosive yield equivalent to 13,000 tons of TNT) may not be sufficient to assure the destruction of a specific target. To compensate for limited missile accuracy, it may be necessary to arm it with a thermonuclear or fusion weapon with explosive yield in the megaton range (as much as the equivalent of 1,000,000 tons of TNT or more). This was the experience in most of the nuclear-weapon States - especially France, the Soviet Union and the United States - where long-range ballistic missiles were not developed until reasonable progress had been made with thermonuclear weapons to arm them. 46/

121. There is growing concern that some threshold nuclear-weapon States are following a similar pattern, first developing fission nuclear-weapon capability, then long-range ballistic missiles and finally thermonuclear weapons. So far, there is no evidence that South Africa has taken this final step. Should such evidence emerge, it would offer the strongest confirmation of South African intent to develop "nuclear-tipped missiles".

Notes

1/ See relevant sections in the SIPRI Yearbook 1990: World Armaments and Disarmament, London; Oxford University Press for SIPRI, 1990. In addition, the Director of the Central Intelligence Agency of the United States Government periodically draws attention to the problem in testimony before Congress.

2/ Throughout this study the term rocket is used to refer to any rocket-propelled vehicle that does not rely on aerodynamic lift, including short-range missiles, long-range missiles, civilian sounding rockets and space-launch vehicles. A short-range or tactical missile is an armed rocket for battlefield used usually with a range under 40 km, although some anti-ship and anti-aircraft missiles have ranges up to 100 km. Ballistic missiles are surface-to-surface rockets with ranges of at least 40 km, usually including an inertial guidance system. For the purposes of the present study, a long-range rocket or intermediate-range ballistic missile (IRBM) is capable of carrying a

Notes (continued)

payload of at least 500 kg a distance of 500 to 5,000 km, as defined under the 1987 Soviet-United States Treaty on Intermediate Nuclear Forces. A cruise missile can be short- or long-range, but relies on aerodynamic lift to maintain flight.

3/ Aviation Week and Space Technology, New York, 15 November 1971, p. 13.

4/ These reports originated with the Israeli newspaper Ma'ariv; see Jack Anderson, "Three Nations to Begin Cruise Missile Project", The Washington Post, 8 December 1980, p. B15.

5/ "Missiles: Israël", Air et Cosmos (Paris), No. 848, 21 February 1981, p. 5.

6/ South Africa Sunday Times, Johannesburg, 20 July 1986.

7/ "Cabinet Gives Go-ahead for Cape Missile Site", Rand Daily Mail, 7 December 1983, p. 10; "Go-ahead for Missile Test Range", Paratus, January 1984, pp. 10-12; African Defence Journal, July 1985, p. 33.

8/ James P. McWilliams, ARMSCOR: South Africa's Arms Merchant, London, Brassey's, 1989, pp. 77, 105 and 106; and discussions with Robert Windrem.

9/ Martin Bailey, "South Africa's Island Bombshell", The Observer, London, 28 December 1986; Milavnews, No. 303, Romsford, United Kingdom, January 1987, p. 22.

10/ For cost figures, see Alan Friedman, "The Flight of the Condor", Financial Times, London, 21 November 1989, p. 10; "First Hades Launch", Milavnews, Romsford, United Kingdom, January 1989, p. 12.

11/ James Adams, Israel and South Africa: the Unnatural Alliance, London; Quartet, 1984.

12/ South Africa's plan and capability in the nuclear field, op. cit., paras. 61 and 64; see also chap. VII. Also see Peter Pry, Israel's Nuclear Arsenal, London; Crown Helm, 1984, especially pp. 41-43 and 94-97.

13/ Quotations from Christopher Coker, South Africa's Security Dilemmas, The Washington Papers No. 126, New York; Praeger and the Center for Strategic and International Studies, 1987, p. 90; Ronald W. Walters, South Africa and the Bomb: Responsibility and Deterrence, Lexington, Massachusetts, 1986, p. 66.

14/ David B. Ottaway and R. Jeffrey Smith, "U.S. Knew of 2 Nations' Missile Work", The Washington Post, 26 October 1989, p. A1.

15/ Bill Gerz, "S. Africa on the Brink of Ballistic Missile Test", The Washington Times, 20 June 1989, p. 1.

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16/ "Israeli Missile Liaison Revealed", Milavnews, Romsford, United Kingdom, No. 337, November 1989, p. 20; NBC Nightly News, 26 October 1989.

17/ An alternative calculation, based on the performance of the three-stage Shavit, concludes that the two-stage Jericho can carry a 1,000 kg payload 2,815 km. See Janne Nolan and Albert Wheelon, "Ballistic Missiles in the Third World", in the Aspen Strategy Group, New Threats: Responding to the Proliferation of Nuclear, Chemical, and Delivery Capabilities in the Third World, Lanham, Maryland, University Press of America, 1990, pp. 125-127.

18/ Steven E. Grey, "Israel Missile Capabilities: a few Numbers to Think About", Lawrence Livermore Laboratory, Livermore, California, 7 October 1988 (unpublished).

19/ The original report of United States Government confirmation of Israeli-South African co-operation in the 5 July 1989 rocket test was carried by NBC Nightly News on 25 and 26 October 1989. The story was produced by Robert Windrem and reported by Fred Francis.

20/ R. Jeffrey Smith, "Israel Said to Help S. Africa on Missile", The Washington Post, 26 October 1989, p. A36; Michael R. Gordon, "U.S. Says Data Suggest Israel Aid South Africa on Missile", The New York Times, 27 October 1989, p. 1; "Israel's Deal with the Devil?", Newsweek International, 6 November 1989, p. 52.

21/ "Pik Botha Denies Israeli Missile Links", Johannesburg SAPA, 27 October 1989; in FBIS-AFR, 30 October 1989, p. 18; Steven Weizman, "Shamir Says Israel-South Africa Nuclear Link 'All Lies'", Reuter, 27 October 1989; in FBIS-NES, 30 October 1989, p. 37; "Shamir on NBC Report, U.S. Trip, Peace Process", Jerusalem Television, 27 October 1989; in FBIS-NES, 30 October 1989, p. 34.

22/ Herman Cohen quoted in David B. Ottaway and R. Jeffrey Smith, "U.S. Knew of 2 Nations' Missile Work", The Washington Post, 27 October 1989, p. 34.

23/ Carol Giacomo, "S. African Connection Stall U.S. Computers for Israel", The Washington Times, 9 November 1989, p. 7; "US Denies Super-Computers to Israel", Financial Times, London, 22 May 1990, p. 7.

24/ From 1980 to 1986 SAAF lowered its accident rate from 2.0 to 0.55 serious accidents per 10,000 flying hours, according to Milavnews, Romsford, United Kingdom, No. 312, October 1987, pp. 22 and 23. In 1989 SAAF was not involved in foreign intervention, but still lost at least three Impala jet aircraft to accidents. See "Military Casualties 1989", in Flight International, Sutton, United Kingdom, 16-22 May 1990, pp. 31-39.

25/ The Military Balance 1989-1990, London; Pergamon-Brassey's for the International Institute for Strategic Studies, 1989, pp. 121, 139 and 140.

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26/ African Defence, April 1988, p. 30.

27/ "South Africa May Develop SSMs", Jane's Defence Weekly, 13 July 1985, p. 98; South Africa Sunday Times, 20 July 1986; Vuuren interview in "Engines Priority for South Africa", Jane's Defence Weekly, Coulsdon, United Kingdom, 2 April 1988.

28/ Buccaneer range is given in John W. R. Taylor, ed., Jane's all the World's Aircraft, 1970-1971, London; Sampson Low, Marston, 1970, pp. 219 and 220. On the Mirage-III, see Taylor, ibid., 1982-1983, pp. 60 and 61. The Cheetah Mirage-III modernization programme does not appear to have affected the aircraft's maximum range significantly. On the Mirage F-1, Taylor, ibid., 1988-1989.

29/ Richard K. Betts, "Paranoids, Pygmies, Pariahs and Non-proliferation", Foreign Policy, No. 26 (Spring 1977), pp. 157-183; Robert E. Harkavy, "Pariah States and Nuclear Proliferation", in George H. Quester, ed., Nuclear Proliferation: Breaking the Chain, Madison, University of Wisconsin, 1981, chap. 7.

30/ Aaron Karp, "Space Technology in the Third World", Space Policy, vol. 2, No. 3 (May 1986).

31/ "South Africa Examining Possibility of Space Programme", African Defence Journal, Paris, May 1989, p. 36.

32/ "Steyn: Space Research Needs to Continue", BEELD, Johannesburg, 31 May 1989, p. 10; in JPRS0TND, 18 September 1989, p. 1; "Commentary Weights Space Program, Costs", Johannesburg Domestic Service, 1 June 1989; in FBIS-AFR, 1 June 1989, p. 13; "Government Cancels Proposed Space Program", SAPA, Johannesburg, 30 May 1989, ibid., 8 June 1989, p. 13.

33/ William J. Broad, "Non-Superpowers are Developing Their Own Spy Satellite Systems", The New York Times, 3 September 1989, p. 1; Hugh De Santis, "Commercial observation satellites and their military implications: a speculative assessment", in The Washington Quarterly, vol. 12, No. 3, summer 1989, pp. 185-200.

34/ Jeffrey Richelson, "Military Intelligence-SPOT is not Enough", Bulletin of the Atomic Scientists, September 1989, pp. 26 and 27.

35/ This conclusion remains consistent with the findings of an earlier report, South Africa's plan and capability in the nuclear field, op. cit.

36/ For general discussions of the issues and technologies involved, see Robert Salvy and Guy Willis, "In-flight Refuelling: Greater Flexibility for Air Power", International Defence Review (Geneva), No. 11, November 1989, pp. 1509-1516; Brian Wanstall, "Tankers Boost Combat Credibility", Interavia, Geneva, No. 6, July 1989, pp. 559-564.

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37/ Milavnews, Romsford, United Kingdom, No. 304, February 1987, pp. 22 and 23; ibid., No. 315, January 1988, p. 25.

38/ Christopher F. Foss, ed., Jane's Armour and Artillery 1989-1990, Coulsdon, Surrey, Jane's Information Group, 1989. SRC later developed similar technology to develop a 210 mm howitzer for Iraq with a rocket-propelled shell giving a range of 57 km, the longest of any contemporary artillery system. The weapon was displayed by the Government of Iraq at a military exposition at Baghdad in April 1989. SRC's President, Dr. Gerald V. Bull, also designed rocket-propelled artillery for ranges of several thousand kilometres, which he described in Bull and Charles H. Murphy, Paris Kanonen - the Paris Gund (Wilhelmgeschuetze) and Project Atmospheric and Space Research, Herford, Germany, E. S. Mittler, 1988, pp. 219-233. This technology remains unproven, nor is there evidence that South Africa has it.

39/ Bernard Blake, ed., Jane's Weapon Systems 1988-1989, Coulsdon, Surrey, Jane's Information Group, 1988.

40/ Georg Johannsohn, "Fuel Air Explosives Revolutionize Conventional Warfare", International Defence Review, No. 6, June 1976, pp. 992-995; Louis Lavoie, "Fuel-Air Explosives, Weapons, and Effects", Military Technology, Munich, No. 9, September 1989, pp. 64-70.

41/ At Shikhany on 3-4 October 1987, the Soviet Union revealed several types of chemical munitions, including warheads for Frog-7 and Scud-B missiles. "Soviets Reveal CW Capabilities", International Defence Review, No. 11, November 1987, p. 1453.

42/ Peter Dunn, ed., Chemical Aspects of the Gulf War 1984-1987: Investigations by the United Nations, Maribyrnong, Australia; Defence Science and Technology Organization, Materials Research Laboratories, November 1987.

43/ Landgren, Embargo Disimplemented, op. cit., pp. 149-152.

44/ The 500 kg payload limit is used by the member Governments of the 1987 Missile Technology Control Régime to define "nuclear-capable" missiles.

45/ In 1981 the United States licensed the export to South Africa of a vibration test stand that could contribute to development of a nuclear warhead for missile delivery. A dual-use technology with applications in several industries, the licence was controversial at the time. It is not clear whether the test stand actually was exported.

46/ The Chinese case is examined in John Wilson Lewis and Xue Litai, China Builds the Bomb, Stanford, California, Stanford University Press, 1988, chap. 8. On United States decision-making on ballistic missiles and thermonuclear warheads, see Edmond Beard, Developing the ICBM: A Study in Bureaucratic Politics, New York, Columbia University Press, 1976.

V. POSSIBLE PROSPECTS AND THEIR IMPLICATIONS FOR PEACE IN THE REGION

A. The evolving regional environment: two scenarios

122. An analysis of South Africa's changing domestic and regional policies is of fundamental importance in discussing the question of security in southern Africa. An accurate reading of the directions and prospects of such changes is however not easy owing to the fact that the transition process is bound to be gradual, uneven, prolonged and subject to setbacks. In addition, given past history, such profound changes will likely be met by scepticism and disbelief.

123. Nevertheless, if it is the apartheid régime that is fundamentally the enemy of peaceful co-operation in southern Africa, fed South Africa's reliance on military force and power, and even nurtured the development of a nuclear option and a policy of reliance on intimidation and destabilization of its neighbours, then a change in such a régime and its replacement by a State in which power is more genuinely shared also implies a changed strategic perspective. Such a post-apartheid régime will not necessarily be a saintly State but it will have a diminished incentive and strategic rationale for nuclear weapons and will rely less on brute strength or technological leads to intimidate citizens and neighbours.

124. The current transition constitutes a watershed for the country and for regional security. How these developments unfold will affect the analysis of South Africa's current and future policies with respect to nuclear weapons or ballistic missiles. It is worth taking two baseline scenarios to put the issues starkly.

1. Scenario one: more of the same

125. It is possible to take a very pessimistic view of current developments. Whether as a result of deliberate duplicity or from the intrinsic and intractable difficulties of managing a delicate change that requires confidence, magnanimity and trust and the appeasement of extreme elements on both sides of the political spectrum, one could posit an outcome that is similar if not worse than that existing before the current steps towards change.

126. In this scenario the negotiations for internal settlement could be viewed as a "front" or "window-dressing" necessary to show South Africa's good intentions and to slow down demands domestically. This could then be used to gain a let-up in sanctions, a return of South Africa to international organizations from which it had been excluded, perhaps including the Board of Governors of IAEA. South Africa would then seek to bargain its nuclear programme and adherence to the NPT for guaranteed access to technology.

127. This tactic would have a pay-off in other respects too. By prolonging "negotiations", the Government could hope to divide the black community or to show up lack of control of the African National Congress (ANC) and incapacity of the moderates to deliver. Offers that seek to split this community and to co-opt the "coloureds" would be designed to demonstrate internationally the intransigence of

the opposition and to discredit the political option. It would be followed by a return to the läger mentality, to "fortress South Africa", to international defiance and to a policy of regional coercion and intimidation.

128. In this scenario stemming either from deception, deep anxiety and unwillingness to accept fundamental change, or from the intrinsic difficulties of negotiating a settlement satisfactory to the white minority, the current discussions would lead to an impasse resulting in regression to the past. This would imply a renewed and probably intensified reliance on military force whether to coerce the indigenous population or its neighbours. In this context reliance on nuclear weapons - whether for intimidation or for actual use - would probably increase, and ballistic missiles would serve a function of underscoring South Africa's technological lead and its long arm.

2. Scenario two: major change

129. An alternative scenario, based on current trends, would lead to quite different conclusions. In this view, current negotiations between the Government of South Africa and the ANC are a process on which barriers are destroyed and confidence built, while steps are taken that begin to address the fundamental issues in South Africa. Without expecting either a sudden breakthrough or a painless transition, it would emphasize the momentum in favour of progress; it would point not to an irreversible process but to one that picks up speed as barriers are broken. It would look not to an overnight change or conversion by South Africa but to a steady shift in its policies that take into account the transformation of its regional and internal relations stemming from its decision to move towards majority rule.

130. This interpretation of recent events would see apartheid as becoming intolerable domestically and internal repression as an unrealistic option to be used indefinitely, factors that catalysed South Africa's white leaders to reconsider their assumptions. At the same time the regional environment is seen as generally improved, with the accords in Namibia and Angola, including the departure of Cuban forces, and the spectre of the Soviet Union's aid to white South Africa's opponents being a much reduced possibility.

131. Internationally the threat of isolation and pressure has been increased by the end of the cold war. South Africa's blatant racism stood out even more starkly against a background of relaxation of tension in East/West relations. With the major Powers competing much less, the prospect of their co-operating on an issue like South Africa's race policies concomitantly grew.

132. The adherents of this interpretation, those who see a major change occurring, see the more conciliatory attitude on the part of South Africa as a result of its reading of all these events. Under this view, South Africa chose to act now when it still had leverage and options rather than wait for these to evaporate. As the move towards domestic reform has started and the regional environment is less tense and the perception of external threat reduced, so the rationale for all-purpose reliance on the military has correspondingly declined. Not only is military force

of doubtful general utility in an era of negotiations and internal dialogue, but the specific features of apartheid believed to be part of South Africa's motivation for nuclear weapons are being dismantled or superseded.

133. None of this is to suggest that military force will cease to play an important role in inter-State relations. In so far as South Africa would continue to face traditional security concerns, whether under a black or mixed-coalition Government, it is a reasonable hypothesis that it would deal with them with conventional military forces, which could be upgraded and consolidated as needs dictated.

134. However, this is very different from arguing that the incentives for the acquisition of nuclear weapons and/or missiles (always far-fetched and based on worst-case assumptions) continue to exist today. Those who adhere to the view of events sketched in scenario two above, who see major changes taking place, put the emphasis on the psychological barriers that have been breached and the new climate created. Indicative of this change is the statement by the SADF Chief of Staff that his country is moving away from "confrontation" to "negotiation" reflecting a "general move to give peaceful methods a chance". 1/

135. With the passing of apartheid, a system that is being gradually dismantled, the incentive for acquiring nuclear weapons and their means of delivery has been correspondingly reduced. At the same time the costs of continuing on such a course to the extent it is made public, which is bound to happen as power changes and the Government is reconstituted, have increased.

136. There may already be a major disjunction between the technological impulse and momentum that has driven research, development and testing and the political rationale that first stimulated and encouraged it. Dramatic changes in the political motive have devalued its potential utility, decreased its urgency and even undermined its basic rationale. At the same time the inertia of the past and the practical deadlines on an ongoing programme have seen a continuation of the technological side of the programme. The "fit" between the politics and the technology of the nuclear programme thus may be poor.

137. In general, there does not seem to be a basis for increased interest by a white minority Government in nuclear weapons and their means of delivery any more as a result of changes in domestic and regional politics. On the contrary, there seems to be a much reduced political/military incentive for these programmes as a result of the fundamental transformation of the political and strategic landscape that has been and is occurring, and in which neither of these programmes may have much of a useful role to play.

138. On balance, this second scenario of fundamental discontinuity with respect to the past, appears to be the more accurate assessment of the current and prospective situation. Notwithstanding all the caveats that one can muster against any long-term optimism or even of the irreversibility of current developments, the basis for fundamental change has been laid and this has transfigured the regional context.

B. Non-proliferation and a nuclear-weapon-free zone in Africa

139. It is generally recognized that most of the serious issues affecting southern Africa's security, though not all, have stemmed in large part from the nature of the apartheid régime in South Africa. The domestic domination and repression of the majority of the people on racial grounds has had its foreign policy analogue: reliance on "clubs and carrots" to intimidate and divide neighbours. This regional emphasis on coercion and threat has had at its roots a deep doubt about the prospects for the long-run viability of the apartheid system. It was this linkage between domestic régime and strong-arm tactics regionally that characterized South Africa's relations with its neighbours until the recent past. In a vicious circle, just as internal coercion replaced consensus, so did attempts to shore up the apartheid system by force further alienate neighbours and other members of the international community, thus adding to South Africa's sense of isolation and estrangement.

140. The legacy of this experience is a sense of vulnerability on the part of other States in southern Africa owing to exposure to a neighbouring superior military Power. It has also fostered a deep distrust and scepticism regarding South Africa's tactics as well as ultimate aims. South Africa's neighbours are thus not disposed to viewing small changes or steps as substitutes for the fundamental reforms required to dismantle the apartheid system. Nor, until the process of reform is complete, are they inclined to prejudge the end result or reduce pressures (e.g. sanctions).

141. Aware of the difficulties inherent in the transition process, which is neither irreversible nor easy, they anticipate a difficult, possibly lengthy period in which several elements will be competing, not all of them moderate or constructive. The outcome of the process is thus not assured and regression cannot be discounted. In this context, it is quite possible that the current mood in regional relations could be rapidly dispelled by a reversion to hardline tactics. In such a case, the issue of South Africa's continuing non-adherence to the NPT and reports of the development of ballistic missile technology will appear more ominous and plausible than would be the case if a positive outcome of the current negotiations could be predicted with any confidence.

142. Today as a result of changes under way over the past few months, there is a sense of palpable movement and opportunity, tinged with hope and trepidation. There is a realization that politics in the region are at a watershed, that the policy of reliance on superior force could be replaced by one based on regional consensus. In this setting, the possibility of fully implementing past Organization of African Unity (OAU) and General Assembly resolutions on the denuclearization of Africa, by the adherence of South Africa to the NPT, becomes a live one.

143. In advance of that, there is a clear need for South Africa to act with dispatch to conclude safeguards agreements on all its nuclear installations. In the light of the experience of Chernobyl, the environmental implications of plant accidents or failures can scarcely be considered national issues; at the least they are of regional, if not global concern. The lack of agreement with IAEA on all

installations creates concern about the quality of management, expertise and control of the facilities and raises concern about regional security, which may be endangered from accidents resulting from poor plant maintenance, engineering and so on. From the point of view of the front-line States, this is an area where South Africa's good intentions can be tested immediately - before the final outcome of the present negotiations.

144. Given a choice between a South Africa without the apartheid system and an apartheid South Africa that joins the NPT, the perspective of the front-line States is that without apartheid the nuclear issue will take care of itself. There is a recognition that with changes in South Africa the self-inflicted sense of insecurity and belligerence will dissolve and with them the need for keeping open a nuclear "option" and keeping facilities outside of the IAEA safeguards system.

145. It is premature to discuss in detail the prospects for a nuclear-weapon-free zone in Africa except to note that when South Africa joins the NPT, there will remain few if any incentives for its neighbours not to follow suit rapidly. The formal establishment of a nuclear-weapon-free zone would be most compelling after a swift adhesion to the NPT by South Africa.

Notes

1/ Jane's Defence Weekly, 18 November 1989, pp. 1104 and 1105.

VI. CONCLUSIONS

146. As has been emphasized from the outset of the present report, whatever conclusions can be drawn from the technical/military capability side of the analysis - and necessarily much of this is ambiguous given uncertainties and secrecy - they must be balanced and tempered both by the difficulties of inferring intentions from capabilities (some of which are by nature dual-capable technologies) and by the political context in which these assessments are made. In this respect recent political evolution in South and southern Africa has been such as to create rather different considerations from those prevailing in the past.

147. Military considerations, despite their obvious importance, will not be the principal element in future decisions and even they cannot be divorced from their political context. The prime question in this connection will be the nature of the future South African State and its relations with its neighbours. It is difficult to imagine scenarios where a post-apartheid South Africa, whatever the nature of its relations with its neighbours, puts a high priority on developing nuclear weapons and/or ballistic missiles.

148. South Africa's white minority Government can look forward to a difficult and delicate transition period, but the outlines for a just and mutually acceptable settlement are discernible and the prospects are better than they have ever been. In this setting, missile technology intended for military application has very limited practical diplomatic or military use. It would do nothing to relieve the pressures making for compromise and negotiation and would serve only to aggravate relations with neighbours, the major Powers and the West. Furthermore, South Africa wants to avoid the imposition of new sanctions and to end current restrictions on its access to international organizations, markets and technologies.

149. The allocation of shrinking defence resources to such weapons would not make much sense either, although this need not imply a total cancellation of existing programmes. The Deputy Defence Minister suggested in an international briefing that "missile development would continue and would probably be applied in the communications field". 1/ This would appear to be a plausible reflection of the direction of policy in light of the foregoing analysis.

150. Thus, taken together, all these factors have a direct bearing on the context and the substance of the issues addressed in the present report:

(a) South Africa has a long-range rocket programme and fired a rocket some 1,400 kms into the South Atlantic on 5 July 1989.

(b) The South African missile programme relies on foreign technology from various foreign sources. The only source of officially licensed foreign missile technology today is Israel. Much additional technology is acquired clandestinely and illegally.

(c) The country cannot build its own long-range rockets without large-scale foreign assistance. The number of long-range rockets and the amount of relevant technology it possesses is not known.

(d) With a strong national commitment, South Africa possibly could build a ballistic missile force within 10-15 years; with massive foreign assistance this might be reduced to 5-10 years.

(e) Through the foreseeable future, however, the country will rely on manned aircraft for long-range attack, including possible delivery of weapons of mass destruction. (Aerial refuelling also can substitute for ballistic missiles although artillery cannot.)

(f) Long-range missiles can be used to deliver conventional or chemical or biological weapons, although their military effectiveness in these cases is debated and uncertain.

(g) If South Africa deploys long-range missiles, these are most likely intended to carry nuclear warheads. South Africa could encounter a long and difficult development effort in adapting nuclear weapons for long-range missile delivery.

(h) South Africa's long-range rocket programme can serve not only military roles; it may support commercial or diplomatic objectives or be part of the national space research programme. It may also serve to launch military reconnaissance satellites.

(i) The regional security environment has become far less adverse for South Africa, reducing any incentives it may have had in the past to seek advanced missile or nuclear capabilities for military purposes.

(j) Current negotiations regarding majority rule in South Africa may change many dimensions of the definition of security in South Africa:

(i) They reduce the incentive for a nuclear deterrent whether versus regional States, for internal purposes or for bargaining with the great Powers;

(ii) They give security a more political, less military dimension;

(iii) Similarly they change the pattern of relations with neighbours from a predominantly adversarial one to one of potential co-operation.

(k) These changes provide the opportunity for a foreign policy that complements domestic changes; one example of this would be adhesion to the NPT and full-scope safeguards. This would greatly inhibit the possible acquisition of nuclear warheads for missile delivery. At the same time it would provide reassurance about the management, techniques and safety of the civil programme as well as serve as an earnest of peaceful intentions. This kind of assurance about South Africa's intentions regarding its nuclear programme could further enhance confidence about the general and fundamental trend in South Africa.

(l) It has been emphasized that the timing of such a move might be critical and that its maximum impact and diplomatic benefit for South Africa would be in the near future.

(m) South Africa in time could become the regional centre for technology and research and benefit from its infrastructure and expertise in nuclear energy as well as in propulsion and missile technology. There are peaceful applications for these that might benefit from the economies of scale. In time, a South Africa without apartheid could resume its place in major international organizations and possibly reclaim its seat on the Board of Governors of IAEA.

(n) The hope for a truly denuclearized continent could be realized and surpassed with regional co-operation established in technology and science. In that case past investments would bear fruit regionally and contribute towards mutual prosperity and peaceful relations.

Notes

1/ BBC Summary of World Broadcasts (ME/0685/B/5), 10 February 1990.

APPENDIX I

Background to South African military-industrial development and current missile production capabilities

A. South African military-industrial development

1. Responses to the United Nations arms embargo

1. South African efforts to acquire long-range rockets are part of a larger national programme to procure modern weapons and advanced technological capabilities. Under the pressure of Security Council resolutions 181 (1963) and 182 (1963) (7 August and 4 December 1963) calling for a voluntary embargo on foreign military assistance to South Africa and the mandatory arms embargo established by Security Council resolution 418 (1977) (4 November 1977), South Africa greatly expanded its military-related industries. As noted previously, nuclear-weapon capability was probably achieved by the early 1980s. Production and modernization of conventional weapons, including aircraft artillery, armoured vehicles, missiles and naval vessels has been, if anything, even more successful. Development of long-range missiles can only be understood in terms of this larger programme for military self-sufficiency.

2. Imported technology continues to play an essential role in many if not all of these projects, mostly acquired illegally or through clandestine official contacts in violation of the United Nations embargo. Similar processes have been used to acquire foreign technology for projects ranging from the Valindaba uranium enrichment facilities to the G-5 155 mm howitzer and blueprints for Type-209 submarines. Long-range rocket technology has been acquired through comparable means. Relying on clandestinely acquired foreign technology, such projects are uniquely vulnerable to disruption. It comes as no surprise that most of South Africa's military-relevant development and manufacturing projects are shrouded in secrecy and that the information available on all such projects is limited.

3. South Africa's missile capabilities have emerged out of a large military-industrial and advanced technology infrastructure with an extensive history of developing equipment for the Government of South Africa. This infrastructure and the patterns of its experiences have shaped the country's long-range rocket research in unique ways. While the physics of rocketry and the engineering of technical solutions ensure that rocket programmes in all countries share many characteristics, the unique pressures confronting militarily relevant endeavours in South Africa have forced its long-range rocket activities to follow the tried and proven South African formula for weapons development. Among the distinguishing characteristics of this approach is the preference to rely as much as possible on foreign technology (often acquired clandestinely), modifying and updating existing equipment or designs to meet new needs, adapting dual-use equipment for military applications, conserving resources through incremental development and altering military requirements to coincide with the availability of technology. This pattern is readily seen in the country's development of weapons as diverse as armoured vehicles, artillery, air-to-air missiles, the Cheetah

fighter aircraft based on the Dassault Mirage-III and a series of attack helicopters based on foreign-designed transport and utility versions.

2. Military-industrial institutions

4. The two institutions that dominate the procurement of military equipment in South Africa are CSIR and ARMSCOR. With near monopolies over advanced research and manufacturing, respectively, their responsibilities are virtually comprehensive, with the important exception of nuclear research, which is the domain of the independent Atomic Energy Board.

5. Both CSIR and ARMSCOR can trace their origins to large-scale arms production undertaken during the Second World War. In 1945, CSIR was formed to co-ordinate the nation's major research laboratories and development centres. Its military activities were separated in 1954 through the establishment of the National Institute for Defence Research (NIDR), which remains under overall CSIR authority. This body co-ordinates military research among specialized independent laboratories, the armed services and university departments. Most of the research organizations relevant to long-range rocketry are within NIDR, although some are located elsewhere under the CSIR umbrella. 1/

6. Military production centres around ARMSCOR, the State-owned corporation that has come to symbolize South African technological prowess and its resistance to the United Nations arms embargo.

7. South Africa emerged from the Second World War with a significant arms production establishment. As a member of the British Commonwealth, its military factories were devoted to licensed production of British-designed equipment in support of the Allied war effort. After the war these facilities were allowed to atrophy and went through several reorganizations. In 1964, the year following the imposition of the first United Nations embargo, these government-owned ordinance plants were placed under the control of the Armaments Production Board. The first of 10 subsidiaries, Atlas Aircraft Corporation, was also established that year. In 1968, the Development and Production Act established ARMSCOR as the independently chartered production arm of the Armaments Board. Eight years later, in 1976, ARMSCOR took over the Armaments Board. Its position was further strengthened by the transfer of some research and development responsibilities from the NIDR in 1978. 2/

8. Today ARMSCOR is largely autonomous, with a seat on the Defence Planning Council, the body chaired by the Minister of Defence, which co-ordinates South African national security policy. Employment reached a peak of 33,000 in 1984 before being trimmed to 23,000 in 1986. Annual turnover is not made public, but the ARMSCOR chief executive told interviewers in 1988 that it was roughly R 3 billion ($US 1.25 billion). 3/

9. In addition to the research and development facilities of CSIR and NIDR, ARMSCOR is supported by over 1,000 private sub-contractors, including many of South Africa's largest manufacturing enterprises. Private firms have a leading role in some sectors, especially military trucks, armoured vehicles and naval vessels. The total employment through armaments development and production totals at least 100,000. 4/

10. It is difficult to ascertain the total value of South African military production. The best indicator is the Special Defence Account, which includes most South African research and development equipment as well as purchases from abroad. For fiscal year 1990/91 it amounts to over 57 per cent of the defence budget, or R 5,746 million ($US 2,210 million). 5/ This figure does not, however, include the value of arms exports.

3. Growing reliance on clandestinely acquired technology

11. Since the mid-1960s, South Africa has been compelled by the tightening international arms embargo to adjust its military procurement strategies. The expansion of ARMSCOR has made it possible to replace most direct imports of major weapon systems with domestic production. Before 1963, South Africa purchased most of its military equipment directly from the United Kingdom. British adherence to the voluntary embargo led South Africa to rely more on arms and production licences from Belgium, France and Italy. 6/ SADF still had to import its most advanced weapon systems such as supersonic aircraft, main battle tanks and surface-to-air missiles.

12. By the mid-1970s, however, direct purchases of major weaponry were becoming more difficult to arrange. In 1975, French President Giscard d'Estaing announced that France, then South Africa's most important arms supplier, no longer would issue new sales agreements for "long-range or aerial arms", although it continued to honour standing agreements. 7/ The imposition of the mandatory United Nations embargo in 1977 exacerbated the pressure on South Africa. Increasingly, Pretoria cultivated clandestine arrangements on the grey and black markets. In the late 1970s and early 1980s, it had notable success importing tanks, small arms and ammunition from brokers in North America, Eastern and Western Europe. Israel also emerged at this time as one of the few Governments willing to license new sales of arms and military technology.

13. Increasingly, however, direct arms transfers and co-production licences were replaced with transfers of technology and assistance for ARMSCOR projects. By acquiring technology and assistance from sympathetic Governments, from others with loose export restrictions for dual-use technology and through illegal smuggling and black market purchases, South Africa was able to sustain its growing military-industrial capabilities. The importance of clandestine technology imports was suggested by the Chairman of ARMSCOR in a 1983 interview when he stated that South Africa produced 74 per cent of its war material. When asked if the remaining 26 per cent was acquired clandestinely, he answered yes. 8/

14. ARMSCOR manufactures few major weapon systems of its own design. The exceptions include air-to-air missiles, artillery and artillery rockets. A private firm, Sandock-Austral, has manufactured a successful series of light, wheeled armoured vehicles of its own design. Most of South Africa's arms production, however, concentrates on updating and modernizing older, foreign-designed systems. In some cases, such as wheeled armour and helicopters, this has been accomplished by modifying the designs of systems manufactured locally under licences issued prior to the 1977 embargo. In a few cases it has been necessary to modernize older weapons in the armed forces inventories with new sub-systems. Examples of this include the Cheetah fighter, a modernization of the French Mirage-III fighter and the Olifant main battle tank, a modernization of the British Centurion tank.

4. Technological and financial barriers to innovation

15. South African military procurement today is limited primarily by two factors: access to foreign technology and finances. Unlike most emerging military powers, South Africa cannot specify military requirements and then purchase the appropriate technology. Instead, the United Nations embargo makes it necessary for South Africa to follow a course of least resistance, developing those military-industrial sectors where technology can be acquired. In the words of the ARMSCOR's Chairman, "armaments development is a question of developing what is available". 9/ A particular problem for South Africa is its inability to purchase foreign weapons platforms. While ARMSCOR has demonstrated an impressive ability to modernize old fighter aircraft, tanks and other platforms, there are limits to the modernization process. Updating quickly reaches a point of marginal returns, after which the inherent limits of a weapons platform configuration impose tremendous barriers to improving performance. Moreover, these platforms are being lost continuously through attrition and age. Despite its ability to acquire military technology and assistance, South Africa has not been able to find a substitute for foreign sources of major weapons.

16. This problem is compounded by the financial burdens of its military programme. South African defence spending rose from R 317 million in fiscal year 1971/72 to R 10,071 million ($US 3,874 million) in fiscal year 1990/91. Budget increases were necessitated not only by the process of modernization going on around the world, but also by the costs of developing indigenous military industries in the face of the United Nations embargo, by the cost of maintaining a massive domestic security apparatus and by the cost of intervention in conflicts in Angola and Namibia. 10/ During these years the value of the rand depreciated considerably, which aggravated the burdens of importing military and military-related technology, making it difficult to finance new weapons projects. 11/

17. Pressures mounted in the late 1980s to reduce military outlays following the withdrawal of South African forces from Angola and Namibia, as well as the erosion of perceptions of the communist threat to which South African leaders traditionally pointed to justify the country's military programmes. 12/ Changes in the international environment prompted a statement by President F. W. de Klerk in December 1989 that major defence reductions would be forthcoming. On 21 January 1990, it was announced that the Army would drop 11 major equipment

projects and stretch out 49 others. The Air Force was to disband four squadrons, mostly of obsolescent aircraft such as the 35-year-old British Canberra bombers. The Navy would have to discharge 2,000 servicemen and civilian employees, almost 25 per cent of its personnel.

18. Under the reductions ARMSCOR was expected to cut its labour force by 2,100 - about 10 per cent. The only major ARMSCOR project known to be affected is the XH-2 Rooivalk attack helicopter under development, by Atlas Aircraft, to SAAF specifications. Under the budget reductions, development of the helicopter will continue, but it will not advance beyond the prototype stage unless a foreign client can be found. 13/ Changes in the status of other South African military-industrial projects have not been made public.

19. Budgetary reductions will increase ARMSCOR's reliance on arms exports. Since the late 1970s, the Government of South Africa has increasingly encouraged its arms manufacturers to seek export outlets. The extreme secrecy of ARMSCOR's early years has yielded to a more open and business-minded approach, especially since 1982, when ARMSCOR displayed some of its products at an international arms exhibition at Piraeus, Greece. In 1983, it began to advertise selected products in the defence industry press.

20. Initially, in the 1970s, South African arms transfers consisted largely of Soviet-style weapons, mostly second-hand or captured. These were secretly distributed to friendly insurgencies for disruption of neighbouring southern African States. Cash sales based exclusively on economic motives gradually became larger. The sales campaign has seen exports of military equipment rise from an average of about $US 10 million annually in the early 1980s to roughly $US 80 million in 1987. 14/ ARMSCOR claims to have found clients in some 30 countries in Africa, Asia, Latin America and the Middle East. 15/ It has been most successful exporting less technically complex items such as light armoured vehicles, artillery and ammunition. The Government of South Africa has shown that it is willing to license exports of more sophisticated weaponry, including missiles, but the only known sale of missiles was a transfer to Chile in 1981 of a second-hand Cactus surface-to-air missile battery. 16/ As financial pressures worsen, ARMSCOR may begin to market its advanced missile systems more aggressively.

B. Current missile-manufacturing capabilities

1. Origins of the missile industry

21. Like most countries other than the major Powers, South Africa's first experience with missiles or rockets came through the purchase of short-range tactical systems from the major Powers. In 1956, United States AIM-9B Sidewinder air-to-air missiles were purchased to arm F-86 Sabre fighters from Canada. The purchase of French Dassault Mirage-III fighters in 1963 similarly included a contract for Matra R.530 air-to-air missiles. 17/ Through these and later deals SADF became familiar with the operation and maintenance of missile ordnance, with the process of promulgating military requirements and specifications. This contributed to the skills that later facilitated the development of a domestic missile industry.

22. The missile sector of the defence industry began to emerge in 1964 with the establishment of the Rocket Research Institute (RRI) under the auspices of the University of Pretoria and CSIR. RRI was built up with assistance from several organizations in Germany, including the Max-Planck Institute for Aeronomy, the Institute for Stratospheric Physics at Lindau-Harz and the Herman Oberth Society of Bremen. A test range was set up at Tsumeb in Namibia. 18/ The early role of RRI has not been disclosed, but the German organizations involved in its establishment were engaged largely in atmospheric research with sub-orbital sounding rockets, suggesting that RRI initially had the same civilian task. A. J. A. Le Roux, then CSIR Vice-President (later President of the Atomic Energy Board), stated in an interview that the new institute would give the country a "foothold in space and weather research", but added more ambiguously that "the Republic of South Africa has been forced by events in Africa to enter the missile field". 19/

23. In 1964, while South Africa lacked the laboratories and industries to develop major missile systems itself, an arrangement was concluded with the Government of France to develop a new medium-range surface-to-air missile system for SADF. The system, designated Cactus in South Africa and marketed internationally by France as Crotale, was designed to South African specifications with the participation of South African engineers and scientists. Development was conducted by the French firms Hotchkiss-Brandt, Matra and Thompson-CSF. The South African contribution to research and development financing has been estimated at 85 per cent. 20/ The existence of the programme was only revealed in 1969 in an announcement to Parliament by the Defence Minister. The first consignment of operational Cactus missile batteries and radars were received in 1971, and at least 54 launch systems were delivered by France up to 1985. It has been argued that South Africa helped finance development of the French Nord AS-20/30 air-to-surface missiles and other systems acquired in the 1960s and 1970s as well.

24. As the Cactus programme entered its final test stage in 1968, the Defence Minister announced plans to build a test facility at Saint Lucia, at a coastal site 240 miles north of Durban and 90 miles from the border with Mozambique. Built with the assistance of unnamed European firms, the Saint Lucia test range was for joint use by CSIR, arms production organizations, the armed forces and civilian research. The establishment of a fully instrumented test range was the first hard evidence of South Africa's intention to develop its own major missile systems. Another important support facility was the propulsion division of NIDR set up at Somerset West in 1973 to develop missile propellants and engines. 21/

25. In 1978, these facilities were integrated along with the former Eloptro, a maker of optical components at Kempton Park, into a new ARMSCOR subsidiary, Kentron, headquartered at Pretoria. As the guided missile division of ARMSCOR, Kentron's activities include missile development and manufacture, missile components, fire control and guidance, tracking, and remote piloted vehicles. Its staff of 1,600 are divided among four short-range weapon systems, engineering and sub-systems, and operations support. 22/ Little more has been revealed about the highly secretive company.

2. Concentration on short-range, battlefield systems

26. Only two missile systems of South African design and manufacture are known to have been fully developed: the Valkiri multiple rocket launcher and the V3 Kukri air-to-air missile. Although neither is a long-range system, they provide a useful impression of South African capabilities in the field of missile and rocketry research.

27. The Valkiri is a 127 mm artillery rocket for army use on the battlefield. Capable of launching salvos of 24 rockets, each weighing 30 kg to a range of 22 km, it was unveiled in 1980. Development started in 1977, reportedly after the South African Army was impressed with Soviet-designed BM-21 rocket launchers captured the previous year in Angola. 23/ The Valkiri rockets are based upon designs and approaches pioneered during the Second World War. Comparable weapons have been developed and manufactured by many countries during the 1970s and 1980s, including Argentina, Brazil, Czechoslovakia, Israel, the Democratic People's Republic of Korea, and by Taiwan, Province of China. Some authors maintain that Kentron probably received design assistance from an outside source - Israel and Taiwan, Provice of China, have been suggested in this context repeatedly. 24/ Although the possibility of foreign assistance cannot be excluded, there are numerous precedents for countries with similar or less advanced military industries developing comparable weapon systems themselves. In 1980, Kentron was awarded the national prize of the Associated Scientific and Technical Societies of South Africa for the Valkiri development, which suggests that foreign contributions were minimal. 25/

28. Compared to the straightforward development of the Valkiri rocket launcher, development of the V3 Kukri air-to-air missile was protracted and frustrating. A prototype designed air-to-air missile, reportedly named Whiplash, was test fired at the Saint Lucia test range as early as December 1968. 26/ During the next few years the Defence Ministry repeatedly announced the imminent unveiling of the new missile. The project appears to have been redirected during the 1970s to rely on concepts and sub-systems patterned on the United States AIM-9B Sidewinder missiles already with SAAF and, more importantly, the French R-550 Magic acquired in 1972 to arm Dassault Mirage F-1 fighters.

29. When the Kukri was made public in 1982, defence industry observers noted its resemblance to the French R-550. Both are infra-red guided, short-range missiles, sharing similar airframes and aerodynamic surfaces. Like the R-550, the Kukri is intended to arm Mirage fighters in SAAF. Although the first operational version of the missile, the V3B, was slightly smaller than the French R-550, a newer V3C version is externally identical to the French missile. Internally, however, the South African missiles are entirely different. 27/ The Kukri clearly is inspired by the French missile and intended to be fully compatible with it, but the South African missile is a distinct design, distinguished by unique flight parameters, target tracking ability and a unique helmet-mounted sighting system enabling a pilot to guide the missile simply by looking at a target. The status of the programme remains unclear. The Kukri does not appear to be in large-scale production, although development of a more advanced third-generation version continues.

30. Foreign criminal investigations in the later 1980s cast light on two other South African missile projects: a shoulder-fired surface-to-air missile and an anti-tank weapon. These projects indicate that ARMSCOR continues to emphasize small tactical missiles, and that it relies on clandestine acquisition of key foreign technology to make progress.

31. On 21 April 1989, three South African diplomats were apprehended in Paris while purchasing components and a model of the Blowpipe shoulder-fired surface-to-air missile from members of the Ulster Resistance, a Northern Ireland Protestant paramilitary organization. The Blowpipe items originally were stolen from their manufacturer, Shorts of Belfast. 28/ South African President Botha later sent a personal apology to British Prime Minister Margaret Thatcher, but not before South Africa had reportedly recruited two British missile technicians from Shorts to work on an unspecified missile project. The men were experts on the Blowpipe and engaged in development of a more advanced version, the Starstreak. 29/ This was the first public evidence of South Africa's interest in manufacturing a comparable system. The incident also showed that ARMSCOR continues to apply its traditional approach of basing its work on foreign designs.

32. A related affair occurred in November 1989, when two Americans and three South Africans were indicted in a United States federal court for conspiring to ship 38 gyro guidance units to South Africa through an Israeli "shell" company. The gyros, made by Northrop Corporation, reportedly were for diversion to a previously undisclosed anti-tank missile under development by ARMSCOR. 30/ Again, South Africa was clandestinely acquiring a technology for which domestic development was either unfeasible, prohibitively costly or time-consuming. The level of technical sophistication involved is revealing; the gyros used in tactical missiles such as anti-tank weapons usually are significantly less sophisticated than the inertial guidance platforms required for long-range ballistic missiles.

33. The Valkiri, Kukri and other undisclosed tactical missile programmes have enabled South Africa to develop its missile industry, related facilities and a cadre of skilled designers and production managers. But this technical base is probably not sufficient to enable the country to develop long-range missiles indigenously. The double-base propellant engines used by South Africa derive from 50-year old technology, poorly suited to large engine applications. 31/ None use fully inertial guidance platforms required for long-range missiles and rockets (the Valkiri is unguided, the Kukri relies on strap-down accelerometers). Maintenance, count-down and launch procedures also differ dramatically.

3. The question of intermediate missile technologies

34. There have been indications that South Africa is trying to manufacture an anti-ship missile. This would be an important technical accomplishment. With ranges typically of 30 to 70 km, anti-ship missiles could be an intermediate technical step towards development of genuine long-range missile production capability.

35. In 1980, the South African Navy revealed the existence of a new anti-ship missile, the Skerpioen, arming its fleet of Israeli-designed Minister Class fast attack ships. The Skerpioen appears to be identical to the Israeli Aircraft Industries Gabriel-II missile, weighing 520 kg, with a range of 36 km. It is not known whether the South African missiles are imported directly or manufactured to some degree in South Africa. The authoritative Jane's is uncertain, noting that "Launchers are made in South Africa, and a number of components, but the extent to which the SAN (South African Navy) is independent of Israeli sources is not known". 32/ Considering the limited quantity of Skerpioen/Gabriel-II missiles in the South African Navy inventory - probably no more than 200 - indigenous development or co-production would impose serious economic penalties, possibly tripling procurement costs over that of direct importation. 33/ Limited local assembly in South Africa is more likely.

36. There has also been speculation in the press regarding South African production of the French Aérospatiale Exocet anti-ship missile. In 1982, a few months after the Falklands war, the executive manager of ARMSCOR announced that the company planned to produce a missile similar to the Exocet. 34/ South African officials were at pains to deny rumours that the country had already acquired actual Exocet missiles, possibly from Argentina. Other sources indicated that plans for various versions of the missile had been acquired from an unnamed Asian country. 35/ The issue was muddled further by a biography of President P. W. Botha published in 1984, which quotes the former Defence Minister saying that South Africa helped finance French development of the Exocet in the 1960s. 36/ The question of a future South African anti-ship missile, be it a French-designed Exocet or another type, imported directly or indigenously manufactured, remains unanswerable at this writing.

4. Implications for long-range missile production capabilities

37. It can be concluded that experience with short-range missiles has brought to South Africa much of the infrastructure, skills and resources required for the initiation and conduct of a long-range rocket or missile programme, but there is little evidence that South Africa is capable of fully developing such a rocket or missile without substantial foreign technical assistance.

Notes

1/ These are listed in appendix II.

2/ ARMSCOR is examined in several full-length studies, including: Landren, Embargo Disimplemented, op. cit.; and James P. McWilliams, ARMSCOR, South Africa's Arms Merchant, London, Brassey's, 1989.

3/ Kenneth R. Timmerman, "The South African Armament Industry: ARMSCOR Comes of Age in Times of Turmoil", Defense and Armament, Paris, January 1986, p. 44; "Engines Priority for South Africa", Jane's Defence Weekly, 2 April 1988. In 1983, ARMSCOR's annual turnover was reportedly around $1.5 billion. African Defence", Paris, November 1983, p. 51.

Notes (continued)

4/ In addition to ARMSCOR employment of 23,000 - currently being reduced to 21,000 - the armaments production and sub-contracting in the South African private sector employ at least 80,000. See Michael Brzoska, "South Africa", in Brzoska and Thomas Ohlson, ed., Arms Production in the Third World, London, Taylor and Francis, 1986, p. 197.

5/ Helmoed-Roemer Heitman, "South Africa Plans 3.6% Cut", Jane's Defence Weekly, 24 March 1990, p. 542.

6/ Although Britain continued to license some sales of sub-systems and components, most prominently granting a licence in 1964 to Atlas Aircraft for co-production of Rolls Royce Viper turbo-jet engines to power locally manufactured Italian-designed MB-326 jet trainers. Sud Aviation of France aided in the design and construction of Atlas Aircraft's main plant at Kempton Park. International Defence Review (Geneva), December 1971, p. 548.

7/ The decision, largely in reaction to criticism by OAU and the Non-Aligned Movement, was announced on 9 August 1975. Edward A. Kolodziej, Making and Marketing Arms: The French Experience and its Implications for the International System, Princeton, New Jersey, Princeton University Press, 1987, p. 370.

8/ D. Villiers and J. Villiers, PW (Biography of P. W. Botha), Capetown, Tafelberg, p. 294, cited in Landgren, Embargo Disimplemented, op. cit., p. 18.

9/ Defence, January 1984, p. 24.

10/ SIPRI Yearbook 1990, Oxford; Oxford University Press for SIPRI, 1990, p. 189, and previous editions. These figures include official defence budgets from white papers on defence or South African press reports and estimates of off-budget defense accounts. The 1990/91 figure is from Helmöd-Römer Heitman, "South Africa Plans 3/6% Cut", Jane's Defence Weekly, 24 March 1990, p. 542.

11/ The impact of depreciation of the rand can be seen more clearly when South African military spending is presented in constant 1988 United States dollars, which reveal that spending reached a plateau at $US 2,970 to $3,206 million from fiscal year 1980/81 to 1986/87, before rising to $3,802 million in 1989. See SIPRI Yearbook 1990, op. cit., p. 194. The constant dollar estimates published by the United States Arms Control and Disarmament Agency are comparable but more erratic, in World Military Expenditures and Arms Transfers 1988, Washington, D.C.; United States Arms Control and Disarmament Agency, June 1989, p. 60.

12/ The role of anti-communism is examined in Robert S. Jaster, South Africa's Narrowing Security Options, Adelphi Paper No. 159, London, International Institute for Strategic Studies, 1980, pp. 4 and 5.

Notes (continued)

13/ "S. Africa Considers Major Force Cuts", Jane's Defence Weekly, London, 20 January 1990, p. 91; "Major Cuts Will Go Ahead in S. Africa", Jane's Defence Weekly, 27 January 1990, p. 139; "Kürzungen in Armee und Rüstungsindustrie Südafrikas", Frankfurter Allgemeine Zeitung, 22 January 1990; Mike Gains, "South Africa Cuts Hit New Helicopter", Flight International, 6 February 1990, pp. 22 and 23.

14/ These figures are from the United States Arms Control and Disarmament Agency publication, World Military Expenditures and Arms Transfers 1988, op. cit., p. 102. The publication presents arms transfer values from United States intelligence sources, reduced in accuracy owing to rounding to the nearest $10 million.

15/ Timmerman, "The South African Arms Industry", op. cit., p. 40.

16/ The Observer, London, 6 February 1981.

17/ Arms Trade Registers: the Arms Trade with the Third World, Cambridge, Massachusetts, MIT Press for SIPRI, 1975, p. 94.

18/ Zdenek Cervenka and Barbara Rogers, The Nuclear Axis: Secret Collaboration Between West Germany and South Africa, London, Julian Friedmann, 1978, p. 233.

19/ Flight, 12 December 1963; The Times, London, 28 October 1963; Southern Africa: the Escalation of Conflict, New York, Praeger for SIPRI 1976, pp. 142 and 143.

20/ The estimate is by Landgren, Embargo Disimplemented, footnote 4, p. 107.

21/ "South Africa to Build First Missile Base", Financial Times, London, 10 October 1968; "S. African Base for Missiles", The Times, London, 10 October 1968.

22/ Ronald T. Pretty, "South African Kukri Air-to-Air Missile", Jane's Defence Review, London, vol. 4, No. 6, June 1983, pp. 515 and 516; Charles Gilson, "ARMSCOR: Sustaining South Africa's Sanctioned Air Force", Interavia, Geneva, No. 11 (November) 1987, especially pp. 1161 and 1162.

23/ Christopher F. Foss, ed., Jane's Armour and Artillery 1989-90, Coulsdon, Surrey, Jane's Information Group, 1989, pp. 704 and 705.

24/ Foreign design of the Valkiri is suggested by Brzoska, Arms Production, op. cit., p. 213; and Landgren, Embargo Disimplemented, op. cit., p. 88.

25/ "RSA Calls the Tune with its own 'Organ'" Paratus, June 1980, p. 28; and "Fearsome Weapon Hits at the Heart of SWAPO", Paratus, June 1982, p. 8.

26/ The New York Times, 3 May 1969; International Herald Tribune, Paris, 18 December 1968.

Notes (continued)

27/ "South African Missile on Show", Flight International, 23 October 1982, p. 1162; "V3B Kukri", Flight International, 29 December 1984, p. 1683; Defence and Armament, Paris, January 1983.

28/ David Mckittrick and David Paskov, "SA in Ulster Arms-for-Secrets Deal", The Independent, London, 24 April 1989, p. 1; Raymond Whitaker, "Failed Deal is a Testament to the Tightening Arms Ban", The Independent, 25 April 1989, p. 2; Patrick Marnham, "Paris Throws out Three South African Diplomats", The Independent, 28 April 1989.

29/ John Carlin and David Mckittrick, "Botha Apologises to UK Over Arms Deal", The Independent, 4 May 1989, p. 1; Mckittrick, "Shorts Missile Men Recruited by SA Embassy", The Independent, 1 May 1989, p. 1.

30/ Nicki Weisensee, "Bid to Sell Gryroscopes to S. Africa Cited", Boston Globe, 17 November 1989, p. 4. One of the Americans and the only South African apprehended in the case subsequently pleaded guilty to the charges. See "Gyroscope Theft Plot Alleged", Boston Globe, 4 January 1990, p. 9.

31/ Double-base propellants, consisting mostly of a mixture of Nitroglycerin and Nitrocellulose, powered virtually all the short-range rockets of the Second World War. Their history is described in Willy Ley, Rockets, Missiles, and Space Travel, revised edition, London, Chapman and Hall, 1957, pp. 171-196. Their technical qualities are outlined in Francis A. Warren, Rocket and Propellants, London, Chapman & Hall, 1958, pp. 8, 9, 28-33 and 43-60; and George P. Sutton, Rocket Propulsion Elements, 3rd edition, New York, John Wiley, 1963, pp. 335-337, 352 and 353.

32/ Bernard H. L. Blake, ed., Jane's Weapon Systems 1988-89, Coulsdon, Surrey, Jane's Information Group, 1988, p. 454.

33/ Each of the 12 Minister Class vessels carries up to 6 Skerpioen missiles. Assuming the Navy possesses three reload rounds for each one deployed (the orthodox counting rule), it should have approximately 162 on hand. A certain number also are expended every year in operational tests, perhaps one missile per ship.

34/ Defence and Armament, September 1982.

35/ The original report appeared in Afrique-Asie, Paris, July 1983. Also see Defense and Foreign Affairs Daily, Washington, 28 July 1983; and "Armscor Refuses Comments on Exocet-Type Missile Plans", African Defence, Paris, September 1983, p. 35.

36/ Villiers and Villiers, PW, op. cit., p. 294.

APPENDIX II

South African nuclear and missile-related facilities

A. Nuclear facilities 1/

1. Uranium supplies and mines

Reasonably assured reserves: 385,700 tonnes milled yellow cake (U_3O_8). Currently active mines: Buffelsfontein, Freegold, Hartebeesfontein, Vall Reefs and smaller mines, total output in 1989 of 7,606 tonnes.

2. Uranium hexafloride (UF6) conversion

Valindaba Pilot-Scale, operation since 1973-1974, unsafeguarded.

Valindaba Commercial-Scale, operational since 1986, unsafeguarded.

3. Metallurgical hot-cell complex

Pelindaba, operational since 1987, safeguarded only when processing safeguarded (foreign-supplied) fuel.

4. Enrichment (of uranium hexafloride)

Valindaba Pilot-Scale plant, jet nozzle process, maximum capacity 50 kg 45 per cent-enriched U-235 annually, start-up 1977, closed 1990.

Valindaba Commercial-Scale plant, jet nozzle process, maximum capacity 50,000 kg 3.25 per cent-enriched U-235 annually, start-up 1988, unsafeguarded.

5. Fuel rod fabrication

Pelindaba, start-up 1981 to supply SAFARI-I reactor, apparently being expanded to supply Koeberg reactors, unsafeguarded.

6. Research reactors

SAFARI-I, Pelindaba, highly-enriched uranium, 20 megawatt, United States supplied, start-up 1965, United States fuel supply stopped 1975-1976, now fuelled from Valindaba-Pelindaba sources, safeguarded.

SAFARI-II/Pelindaba-Zero, low enriched uranium, <1 megawatt, domestically supplied, start-up 1967, decommissioned 1977, United States fuel supply, safeguarded.

7. Power reactors

Koeberg I and II, low-enriched uranium, 922 megawatt each, French-supplied, start-up 1984 and 1985 respectively, initial fuel supply from Belgium, France, Germany and Switzerland, now fueled from Valindaba - Commercial-Scale plant, safeguarded.

B. Missile-related facilities 2/

1. Council for Scientific and Industrial Research (CSIR), Pretoria, established 1945, total employment about 4,600 divided among 16 institutes and laboratories.

(a) National Institute for Defence Research (NIDR), Pretoria, established 1954, co-ordinates military research and development under CSIR authority.

(b) CSIR-NIDR institutes relevant to missile development include: National Institute for Aeronautics and Systems Technology (NIAST); National Chemical Research Laboratory (NCRL); National Electrical Engineering Research Institute (NEERI); National Research Institute for Mathematical Sciences (NRIMS); National Mechanical Engineering Research Institute (NMERI): National Physical Research Laboratory (NPRL).

2. Armaments Corporation of South Africa (ARMSCOR), Pretoria, established 1968, total employment about 23,000 divided among 10 subsidiaries, 1988 total sales approximately R 3 billion ($US 1.25 billion). ARMSCOR subsidiaries relevant to missile development and manufacture include:

(a) Kentron, Pretoria, established 1978, total employment about 1,600, 260 engineers, manufactures Valkiri artillery rockets, V3 Kukri air-to-air missiles, may assemble Skerpioen anti-ship missiles, known to be developing anti-tank and surface-to-air missiles as well as long-range missiles.

Kentron divisions include:

Facilities formerly associated with the Rocket Research Institute established by CSIR, in 1963-1964, Pretoria;

Saint Lucia test range, Natal coast, established 1968, possibly no longer in use;

Somerset West facility, established 1973-1974 as the NIDR Propulsion Division, specializing in rocket fuels, engines and warheads;

Eloptro, Kempton Park, established 1974, total employment 400, about 12 per cent of turn-over missile-related, specializing in automatic guidance components, optics and sighting systems.

(b) Houwteq (or Hotek), Houwhoek, South Cape, established 1987, total employment about 400, may be a Kentron division, supports missile tests and simulations at the Overberg test range.

(c) Overberg test range, de Hoop, South Cape, established 1984, operational 1989, a long-range missile and rocket test flight facility, may be a Kentron division.

(d) Somchem, Cape Town, Kranterop and Somerset West, established 1962, manufactures artillery and rocket propellants, explosives, rocket engine casings, warhead components and fuses.

Notes

1/ Sources: South Africa's plan and capability in the nuclear field, op. cit.; Special Committee against Apartheid, The Development of South Africa's Nuclear Capability (A/AC.115/L.602); Leonard S. Spector, The Undeclared Bomb, Cambridge, Massachusetts, Ballinger, 1988, pp. 286-305.

2/ Sources: Michael Brzoska, "South Africa: Evading the Embargo", in Brzoska and Thomas Ohlson, eds., Arms Production in the Third World, London; Taylor and Francis for SIPRI, 1986, chap. 10; Signe Landgren, Embargo Disimplemented: South AFrica's Military Industry, Oxford, Oxford University Press for SIPRI, 1989; James P. McWillliams, ARMSCOR: South Africa's Arms Merchant, London, Brassey's, 1989; Kenneth R. Timmerman, "The South African Armament Industry: ARMSCOR Comes of Age", Defence and Armaments, Paris, January 1986; Thomas Conrad, et al., Automating Apartheid: U.S. Computer Exports to South Africa and the Arms Embargo, Philadelphia, American Friends Service Committee, 1982, pp. 52-54 and 102-107.